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The Taxation of Natural Resources

Principles and Policy Issues

Robin Boadway
and
Frank Flatters

Developing countries are increasingly aware of the desirability of using taxes to capture a share of the rents from local natural resources. The time has come in many countries when the gains may be much greater if the rather crude forms of resource taxation — such as royalties, production taxes, and export levies — were replaced by simple forms of rent taxes rather than attempting to refine existing taxes further.

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This paper — a product of the Public Economics Division, Policy Research Department — is part of a larger effort in the department to analyze public policy options for natural resource taxation. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Carlina Jones, room N10-063, extension 37699 (October 1993, 57 pages).

Natural resources are typically subject both to taxation under the income tax system and to special resource taxes. Properly designed income taxes attempt to include capital income on a uniform basis. But in most countries the income tax treats resource industries more favorably than most other industries — through favorable treatment of such capital expenses as depletion, exploration and development, and the cost of acquiring resource properties.

The case for special resource taxes is precisely to tax resource rents over and above the levies implicit in general income taxes. There are two justifications for this: (1) the efficiency-based argument that a tax on resource rents is nondistorting and complementary, and (2) the "equity" argument that the property rights to resources ought to accrue to the public at large rather than to private citizens since the rents represent the bounty nature has bestowed on the economy rather than a reward for economic effort.

If the main purpose of a resource tax is to capture rents for the public sector, the base of resource taxes should be economic rents (or their present value equivalent), contend Boadway and Flatters.

Actual resource taxes differ from rent taxes in significant ways. Unlike a general income tax — which allows the resource industries to understate capital income — resource taxes often overstate rents. This is because they typically do not offer full deductions for all costs, especially capital costs. Some systems tax revenues without allowing any deductions for costs; others allow the deduction of current costs only. As a result, they discourage investment activity in resource industries, encourage the exploitation of high-grade relative to low-grade resources, and make it difficult to impose high tax rates for fear of making the marginal tax rate higher than 100 percent.

Boadway and Flatters discuss three alternative "ideal" ways for the government to divert a share of rents to the public sector:

- Levy a tax on rents, ideally in the form of a cash flow tax.
- Require firms to bid for the rights to exploit resources.
- Take a share of equity in the firm.

They discuss these options in terms of their implications for the ability of firms to obtain finance, the allocation of risk, the share of rents accruing to the public sector, the extent of involvement of foreign firms, and other factors.

The time has come in many countries, they say, when gains from further refinement of imperfect existing taxes on resources are less than replacing them with simpler, more efficient forms of pure rent taxes.

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The Taxation of Natural Resources: Principles and Policy Issues

by

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THE TAXATION OF NATURAL RESOURCES: PRINCIPLES AND POLICY ISSUES

by

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EXECUTIVE SUMMARY

Resource taxes are part of the overall system of taxes which impinge upon the incomes of businesses. The system usually includes direct income taxes of a general nature, indirect taxes of various sorts including sales and excise taxes as well as export and import duties, and taxes specifically designed for resource industries.

Income taxes are intended to tax capital and personal income of residents and, where possible, of non-residents earning income in the country of taxation. If designed properly, income taxes tax all capital income on a uniform basis, including both the normal return to capital and any rents. In most countries, however, the capital income tax system treats resource industries quite favourably relative to other industries. This occurs mainly because of the favourable treatment afforded various capital expenses, such as exploration and development, the cost of acquiring resource properties and depletion. The consequence is that equity income in the resource industries is often undertaxed relative to other industries.

The case for special resource taxes is precisely to tax resource rents over and above the levies that are implicit in general income taxes. There are two justifications for this. One is the efficiency-based argument that resource rents are non-distorting. The other one, which is complementary, is that the property rights to resources ought to accrue to the public at large rather than to private citizens, since they represent the bounties nature has bestowed on the economy rather than a reward for economic effort of some sort. This can be viewed as a sort of equity argument.

Given that the main purpose of resource taxation is to capture rents, the appropriate form of taxation is one whose base is economic rents. Actual resource taxes seem to differ from rent taxes in significant ways. Unlike with the general income tax which includes provisions which allow the resource industries to understate capital income, resource taxes often overstate rents. This is because they frequently do not offer full deductions for all costs, particularly capital costs. Some systems tax revenues without giving any deduction for costs; others allow current costs to

be deducted. As a consequence, they discourage investment activity in the resource industries, encourage the exploitation of high grades of resources at the expense of low grades, and make it difficult to impose high tax rates for fear of making the marginal tax rate greater than 100%.

There are three alternative 'ideal' ways for the government to divert a share of rents to the public sector. The first is to levy a tax on rents. The ideal sort of rent tax is a tax on the real cash flows of resource firms. For non-renewable resource firms, the base would include all revenues on a cash basis less all current and capital costs including costs of acquiring resource properties, exploration expenses, development expenses and any processing expenses incurred by the resource firm. For renewable resource firms, similar costs would be deducted including costs of property rights, harvesting costs, any renewal costs such as replanting or restocking, as well as any processing costs done by the firm. There should be no deductions for other taxes paid. Of course, cash flow accounting should be done from a social point of view so any external costs should be included as costs on a cash basis. It may also be necessary to require the firm to cover the external cost associated with shutting down, though that may be done by forcing firms to post bonds and/or through other forms of regulation. Both corporations and unincorporated firms should be subject to the tax.

The principal difficulty with a full-fledged cash flow tax is that it generally implies that tax liabilities will be negative for new and/or growing firms. Fully refundable tax credits are called for in these circumstances. Governments are reluctant to make such payments, and firms are unlikely to believe government commitments to make them. However, this problem can be solved by using a modified cash-flow tax base in which the firm can capitalize cost deductions in a straightforward way. In particular, any costs can be capitalized, and those that are receive a full nominal interest deduction based on the full book value of the capitalized cost.

The second way for the government to share in the rents is to require firms to bid for the rights to exploit resources. In the case of non-renewable resources, this would occur prior to the exploration stage. For renewable resources, the bid would be for a known stock of resources. As long as the bidding system were competitive and all bidders were equally well informed, the value of the bid would be equal to expected future net rents (net of future expected taxes) corrected for a risk factor. For such a system to work, the property rights obtained must be perpetual. Otherwise, there would be an incentive for the operator to extract the resource inefficiently.

Even with a well-functioning auction, the consequences can differ from that under a rent tax. For one thing, the auction will yield 100% of the expected value of the rents to the bidder, whereas the tax rate may be less than that. Under an

auction, the cash flow consequences are much different as well. Net rents must be entirely paid up front, whereas with taxes they are spread out into the future. If there are any capital market constraints, this will be reflected in the size of the bid. Also, the risk effects can be different. Under the auction system, the firm is forced to bear the risk associated with resource exploitation, whereas with the cash flow tax the public sector shares the risk. One important reason why the public sector may be better at dealing with risk is that some of the risk facing the operator is the risk of higher taxes in the future. The time inconsistency which gives rise to this will be more severe under any system. Thus while this risk makes it more appropriate to use an auction system, it also reduces the price that bidders will be willing to pay for a long term lease.

Finally, the public sector may obtain a share of the rents by taking on a share of equity in the firm. One way is for the government to contribute to a share of the costs and claim an equivalent share of the equity. This would be financial equivalent to a cash flow tax, though perhaps more difficult to implement. The public sector would have to identify both the cash costs and the revenues accruing on the relevant operation of the firm. On the other hand, unlike with a cash flow tax, this gives the public sector a say in the decision-making responsibilities that come with share ownership. As well, it may be privy to information that it otherwise would not obtain. With cash flow taxation, by contrast, the government is only a silent partner.

The above method requires the government to provide cash up front. This could be avoided if, instead of being provided with money up front, the firm could deduct its share of the costs later on against dividends. As long as the costs were appropriately deducted with interest, the scheme would be financially equivalent to the cash-flow equivalent schemes outlined earlier. As with taxation but in contrast to auctions, equity participation schemes will divert less than 100% of the rents to the public sector.

Revenue-raising policies actually used will generally differ from those outlined above. This implies that they are not pure rent collecting devices, and hence distort resource allocation decisions as well. In the case of taxes, it has been the exception rather than the rule that rent taxes have been used in the resource industries. Indeed, there are very few examples of cash flow type taxes. We consider the most commonly used taxes.

Perhaps the most common form of resource charge has been a levy based on the quantity extracted, variously referred to as a royalty or severance tax in non-renewable resources and a stumpage fee in forestry. It is difficult to understand the attraction of this type of charge apart from simplicity. Sometimes these levies have been viewed less as a form of tax than as a fee charged by the public sector

for removing resources from public or Crown lands. However, from an economic point of view, they are equivalent to a production tax. In their simple form, they tax revenues with no accounting for costs. As such, they act as a disincentive for investment and extraction of resources and coincidentally generate less revenue for the public sector than could be obtained by a rent tax. Furthermore, since no account is taken of costs, they discriminate against high-cost revenue sources at the expense of low-cost ones. This effect of crude royalty systems is generally known as high-grading of the resource.

The effect of production taxes can differ according to whether the tax rate is based on quantity produced (per unit tax) or upon the selling price (*ad valorem*). In principle, an *ad valorem* rate can always be chosen such that it is equivalent to a given per unit rate. When prices are changing, *ad valorem* and per unit production taxes will have different effects. Since *ad valorem* taxes rise with increasing prices (and vice versa), this implies that an *ad valorem* tax has some risk-sharing effect that the per unit does not have, and in periods of rising resource taxes, it discourages investment more. Similar effects occur when the quality of a resource varies within a given deposit.

Increasingly, royalty schemes have been designed to be more sophisticated than simple production taxes. Some royalty bases have been defined to be revenues net of some measure of current costs. This goes part way towards making royalties reflect rents. Another method is to make the royalty rate itself a sliding scale based on either resource prices (an *excess price tax*) or on the quality of the resource. These are sometimes referred to as *windfall taxes*, reflecting the fact that purpose has been seen as a way of creaming off resource rents generated by price increases. Again, this is an imperfect way of taxing resource rents in general, although it can succeed in obtaining changes in rents from existing resource firms who have benefited from an unexpected increase in price. However, this is done at the expense of discouraging incremental investments.

Resource properties are usually also subject to general income taxes. However, in some instances, taxes specific to the resource industries are also based on some measure of income. In such cases, the tax is often designed in similar ways to the general income tax and has built into it some of the same biases. That is, it affords rapid write-offs for acquisition costs, exploration and development, and often gives a depletion allowance. Although this generates some revenues, it also provides a subsidy to marginal projects. That is, average tax rates are positive while marginal tax rates are negative. Furthermore, the rate of return to equity at which they usually become effective has tended to be extremely high, so that they have not been very effective collectors of excess profits or rents.

Some tax regimes impose an annual rental fee or charge for the use of resource

properties. If their rates were such as to reflect the true capital value of the properties being used, they would be like a rent tax. However, they are typically set at arbitrary and more or less nominal rates. It would be difficult to administer such a tax based on the true economic value of the resource property in question since market values do not exist. Thus, some administrative discretion would be required. If an annual rent tax is to be charged it seems preferable to use a proper rent tax.

In primary product exporting countries, export taxes have been a major source of government revenue. If the country is a price taker on international markets, an export tax has exactly the same effect as a production tax from the point of view of the producers. From this viewpoint, therefore, export taxes share the same difficulties as production taxes in collecting rents for the government. However, consumers pay a lower price under the export tax. Although there may be some distributive reasons for preferring an export tax, most countries have found that export taxes on resource products (e.g. rubber in Malaysia) have been regressive. Taxes on exports to induce local downstream processing industries can also be a very costly way of dissipating resource rents. Even in cases where the resource-exporting country might have a long term comparative advantage in further processing, the use of export taxes to speed up the process can be very costly.

Export taxes may be justified if the country has some monopoly power in world markets by the usual optimal tariff arguments. If so, that would be a separate justification for export taxes over and above rent collection devices.

Auction systems tend not to be used much, especially in developing countries. One reason might be that the conditions do not lend themselves to competitive bidding procedures. Many resource projects are large and may not involve more than one different investor at the same time. For whatever reasons, individual deals are struck with resource producers involving different types of public participation. These can take various forms.

Under the simplest form of production sharing is that in which the government takes a given share of the product. It is analogous to sharecropping in agriculture, and is identical to an *ad valorem* production tax at the same rate. It differs from a tax on pure rent since no costs are deducted. Since it is *ad valorem*, some risk-sharing is implicit in the scheme.

Since production sharing schemes are subject to negotiation, the proportion of sharing could vary from project to project. In this way some account can be taken of different potential rents. However, as long as costs are not explicitly deducted, such schemes will not reflect pure rents.

Some schemes account for costs partially by having the production sharing cut in only after some minimum guarantee level of revenues. As well as allowing the firm to cover some part of initial costs before sharing its output, this provides an additional measure of risk-sharing. However, even if the minimum were set such that total costs were covered, there would still be a marginal disincentive involved once the production sharing begins to apply.

Governments may also negotiate to adopt equity positions in resource firms. At one extreme, the government could simply purchase shares of a resource firm on the open market. Since the market value of the firm should capitalize all expected future net rents of the firm, however, this would not be expected to yield any net revenues to the government. To facilitate rent transfer to the government, the government must succeed in obtaining shareholding privileges at below the market value of the shares.

At the other extreme, the government may simply take "free equity" in the firm, thereby entitling itself to a share of future dividends of the firm. This will differ from a rent tax regime by the fact that no implicit deduction is given for the initial equity put in by the firm. This may approximate the initial capital costs incurred by the firm. It would then be similar to a royalty system with current costs deducted.

Instead of taking free equity, the government may pay some price for it. To obtain some share of the rents, the price would have to be less than the market price of the shares taken. Equity sharing schemes of this form will be equivalent to rent taxes if the payment made by the government is equal in present value to an equivalent share of the cash costs of the project. If this payment is made up front, it would have the identical financial effect as a cash flow tax. The only real difference is that the government obtains voting rights. If the payment is spread out into the future (e.g., taken out of future dividends), it should be carried forward with interest. In either case, the government will obtain only a share of the rents rather than the entire amount. system.

There are a number of other design issues involved in resource taxation which may cause them to differ from ideal rent taxes. Arrangements with the private sector for sharing rents are sometimes specified only for a limited period of time. This may be because of conscious design, or it may be because of the inevitable inability of governments to commit to fixed policies for long periods of time. In any case, the result is an inefficiency which is hard to avoid.

Many non-renewable resource operations face costs of shut-down such as clean-up costs to avoid environmental damage. Simply requiring firms to meet such costs may be unenforceable since they may be able to avoid them by just abandoning

the site. Clean up could be enforced by requiring the firm to post bonds against the cost of cleanup, or, equivalently, by imposing a withholding tax in respect of resource management which is refundable once the clean up is completed.

Some sorts of policies may involve administrative discretion. Economists generally view these sorts of policies with some suspicion and prefer those for which he terms of eligibility are automatic. Discretionary policies often lend themselves to costly rent-seeking behaviour.

In many countries jurisdiction over resources is decentralized at least partly to lower levels of government. This can give rise to problems of tax coordination among various levels of government as well as to different fiscal capacities among lower levels of government. As the literature on fiscal federalism makes clear, the latter can cause inequities across the federation and inefficiency in the allocation of mobile factors of production in favour of the wealthier states. Many countries have instituted mechanisms to enable at least some share of resource rent to be shared among states.

Many of the firms that operate in less developed countries are foreign firms. This gives rise to various other issues. For one, certain tax measures may be preferred to others to the extent that foreign tax crediting is facilitated. Use of the income tax system rather than free equity or production sharing arrangements may have that property. As well, the ability of foreign companies to shift profits through transfer pricing and other means will limit the extent to which some types of taxes on resource rents will be effective. This may help to account for the growing use of other measures such as royalties, equity participation and leasing of property rights.

Developing country governments have become increasingly conscious of the desirability of levying taxes on economic rents arising from natural resources occurring within their boundaries. At the same time they have shown increasing sophistication in modifying the crude fiscal instruments that have been traditionally used for this purpose in order to both decrease the efficiency costs arising from the use of imperfect rent taxes and increase the proportion of the rents that they are able to attach for public purposes. The time has now been reached in many countries at which the gains from further refinement of what are basically very crude taxes such as royalties and export levies might be far exceeded by replacing them with much simpler forms of pure rent taxes.

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I. INTRODUCTION

The raising of revenues from the economic activity associated with the exploitation of natural resources is virtually a universal phenomenon among the nations of the world. This can take several different forms. It may consist of taxes specific to the resources in question. It may involves special measures applicable selectively to the resource industries within more general systems of taxation (such as the corporation income tax). Or, it may consist of varying degrees of public ownership of resource property rights ranging from ownership of the resource being exploited which are sold or leased to private sector resource firms, to joint public-private ventures, to outright public ownership and operation of the resource firms themselves. Our purpose in this study is to concentrate on the use of taxation measures by the public sector to extract revenues from resources industries, especially taxes specific to the resource sector. However, we will not be able to do so in isolation from these other measures, some of which represent relatively close substitutes for taxation. In this introductory section we set the stage for the subsequent analysis by outlined some general features of resource industries and resource taxation found across countries.

It is useful to begin with some discussion of the types of resources themselves. Natural resources consist of the various materials endowed upon a nation by nature which are useful in the production of goods and services. It is common to classify natural resources as being of two broad types, though the distinction is sometimes ambiguous. They are the following:

Renewable Resources. Renewable resources are those that can generate a continuous flow of output for an indefinite period of time. They include such things as fisheries, forests, hydro-electricity, water supplies, clean air and agricultural land. In each case, as some of the resource is taken for economic use, the resource can replenish itself by natural or artificial means A characteristic feature of renewable resources is that the level of flow of resource that can be sustained is an endogenous variable. It can depend upon the stock of the resource that is maintained, upon natural rates of renewal of the resources (e.g., biological rates of growth) and upon conservation and husbandry practices of those exploiting the resources (e.g., replanting of forests,

regulations on the size of fish taken, fertilization practices, use of reservoirs, etc.). In some cases, it is also true that the dynamics of resource renewal are such that extinction of the stock can occur in the case of overexploitation. The tax treatment of renewable resources necessarily involves consideration of the dynamics of the resource renewal process. In some cases, the exploitation may involve a continuous flow of output (e.g., fisheries, hydro-electricity); in others, it may involve a series of cycles of extraction and replenishment, as when clear-cutting is used in forests.

Non-Renewable Resources. Non-renewable resources are those such that, in principle, there is a fixed amount available for use. Two types of industries account for the most important non-renewable resources — hydro-carbon fuels (oil and gas) and mining. The latter, in turn, can be subdivided into metallic and non-metallic mining, and these can be subdivided according to type of resource. Thus, base and precious metals are often distinguished within the metal mining sector, and so on. The two broad categories, oil and gas and mining, share some features in common, but they also differ in some important ways. Both are non-renewable in the sense that there is ultimately a fixed stock of the resource (ignoring the fact that hydro-carbons regenerate themselves over very long periods of time). The stock is, however, typically both of unknown size and of variable quality. Because it is of unknown size, new deposits must continually be discovered and there is an exploration industry which is devoted to that. The tax treatment of exploration activities will be of some importance for our later discussion. The variability of quality can come about because of different concentrations of the resource in a given deposit or of differing costs of extraction. Differences in quality are also important for tax policy since they result in different costs to the economy of obtaining the resource. A related characteristic of non-renewable resources is that they are typically found in impure form, that is, mixed with other elements. This implies that further processing is an important part of obtaining the resource. This, too, will have tax implications. One way in which oil and gas differs from mining is that many of its products can be used only once. Thus, natural gas and engine gasoline are burned off when used. On the other hand, the products of mining can often be re-used. This means that there can be an active recycling industry. In that sense, they approach being renewable resources.

We can summarize the above by listing the possible stages of production for non-renewable resources:

— exploration
— development
— extraction
— processing
— recycling

Processing itself may consist of several steps including concentrating, milling, etc. At any stage beyond extraction, there may also be the holding of inventory, which involves decision-making.

Governments impose a variety of types of taxes and other levies on their resources industries. Taxes of a general broad-based sort, such as the corporate tax and general sales taxes, also apply to the resource industries. However, they often have special provisions applying to the latter. For example, corporate tax systems often allow rapid write-offs for resource activities such as exploration and development as well as special depletion allowances on non-renewable resources. There may also be investment incentives such as preferential tax rates, tax holidays and investment tax credits. Higher sales tax rates may be levied on the consumption of oil and gas products. These broad-based taxes tend to be levied on a *residence* basis, that is, on the tax base of taxpayers resident in the country levying the tax.

Taxes specific to the resource industries are most often applied on a *source* basis, that is, on the tax base in the country where the base is generated. The simplest of these is a specific output or production tax levied on either the output or the revenues of a resource industry. In the mining industry, this is sometimes referred to as a *severance* tax. When the property rights to the resource are owned by the state, it may be referred to as a *royalty*. In the case of forestry, it is sometimes called a *stumpage fee*. The rate may be stated in *per unit* terms or in *ad valorem* terms. It may be a flat rate, or it may be graduated according to price, size or quality of deposit, etc. Production taxes may allow some costs to be deducted from them. In the simplest case, current or operating costs may be deducted. More generally, the tax can be a *profit tax* in which both capital costs and current costs are deductible. The tax treatment of capital costs is an important characteristic of resource taxes since resource industries tend to be relatively capital-intensive. Capital costs may include depreciation of installed capital, interest costs and depletion allowances. There may also be incentives for certain types of activities such exploration, development and further processing. A variation on profits taxation is the so-called *rate-of-return tax* which is a tax levied on rates of return in excess of a cut-off rate.

Another very important variant of profits taxation is the so-called *cash flow tax*. The base for this tax is the real cash flows of the firm defined to be total cash (as opposed to accrued) revenues from the sale of output less total cash outlays on both current and capital inputs as they occur. The full and immediate write-off of all investment expenses implies that there is no need for costing capital on an accrual basis using depreciation and cost of capital deductions. Nor is there any need for indexing. Under this form of a cash flow tax, only real as opposed to financial transactions have tax implications. It is what the Meade Report (1978) referred to as an R-based cash flow tax. It would also be possible to treat financial

purchases and sales on a cash flow basis, and there may be some merit from doing so in industries in which significant profits are generated from financial transactions, such as in financial intermediation. However, in discussing the cash flow tax in the context of the resource industries, our focus will be on the real side of the firm. There are very few instances of a pure cash flow tax, though some countries use partial variants of it. One important reason is the fact that, under a cash flow tax, firms undertaking expansionary investments will typically be in a loss position with negative tax liabilities. Symmetric treatment would require that the government make good these negative taxes, but this is rarely done. That is, *full loss offsetting* is not the rule.

This problem of the tax treatment of losses is a more general one that applies to any sort of tax allowing deductions for costs. It will be of some importance in our discussion of resource tax policy. Typically, tax systems allow *partial loss offsetting* of the following type. Firms in a loss position are allowed to carry the losses backward for a given number of years and forward for a given number of years without interest. If special investment incentives are in place, the ability to offset losses may be affected. For example, if countries offer a tax holiday in which zero taxes are payable, firms may be precluded from carrying forward losses into years in which the tax rate is positive. Naturally, the problem of loss offsetting is only relevant under tax systems in which deductions for costs are allowed from the base. Production or output tax bases could not be negative.

In many countries, resource products are traded on international markets. This gives rise to trade taxes as a form of revenue raising. In the case of an exporting country, an export tax can be used. Its effects will differ from a source-based production tax since domestic consumption of the resource is excluded from taxation. Similarly, resource-importing countries may employ tariffs on resource imports. Equivalent measures such as quotas and licenses can be used in lieu of trade taxes, although their revenues may accrue to the private rather than the public sector.

There are various non-tax measures that could be undertaken by the government to divert revenues from the resource industries to the public sector. These typically involve the direct exercise of property rights by the public sector. One common form this takes is the sale of leases from the public sector to the private sector for the exploitation of a particular resource. This is common in the oil and gas industry, in forestry, in the fishery and in mining industries. The sale often takes the form of an auction in which competing bids are tendered. The auction itself may take various forms, including both sealed and open bidding. Depending on the resource, the lease may involve the right to explore (as in oil and gas) or the right to extract a known source of resource (as in forests and fishing grounds). The terms of leases may vary as well. An important element of a lease may be the

time period over which it applies. The length of the lease or concession may affect the speed with which a nonrenewable resource is extracted as well as the way in which a renewable resource is managed. Only a lease of indefinite duration would be equivalent to full private ownership of the resource property. Note that there may be an interaction between the leasing system and the subsequent taxation if the profits from the resource. The purchase of a lease is an acquisition cost which is typically treated as a cost deductible from the tax base. An alternative would be for the lease to be creditable against tax liabilities. The relationship between leases and profits taxes will be discussed further below. A related measure that can be used is licensing. Firms can be required to pay a license fee to exploit resource properties. Depending on how licenses are allotted and how their prices are set, they can have very similar effects to leases.

Direct public sector participation in resource production is another way of obtaining a share of revenues from resources. This can take the form of joint ventures in which the public sector puts up a certain share of the capital to full public ownership. This bears some analogy with cash flow taxation. As we discuss later, cash flow taxation has the effect of making the government a *silent partner* in the ownership and profits of the firm. Public share ownership makes the government an active partner. As long as the government is not in a position to exercise control of the firm, the results should be similar, with one major exception. For firms in a loss position, public share purchases will be like cash flow taxation with full loss offsetting. It will therefore differ in effect from cash flow taxation with only partial loss offsetting.

The public sector may also engage in regulatory activities which affect the behaviour of resource firms without generating any revenues for the public sector. Various aspects of the resource firm's behaviour may be regulated, from exploration to development through to extraction. In addition to having the disadvantage of not generating revenues for the public sector, regulation is also a discretionary form of intervention which can induce inter-firm distortions on the economy.

Before leaving this introductory section, there are three further institutional features of the resource industries which are worth highlighting. The first is that there is often a significant presence of foreign-owned firms in the resource sector, especially in developing countries. The tax treatment of such firms both by the host country and by its home government is an important determinant of the incentive to invest in the former. Typically, a foreign firm is liable for taxation both at home and in the host country. However, there may be measures in place to reduce the possibility of double taxation. Corporate tax systems typically offer partial tax credits on similar taxes paid abroad. Thus, the United States taxes the profits of foreign subsidiaries of its domestic firms when profit are repatriated and offers a tax credit up to the amount of home country tax liabilities. Similar practices

are applied elsewhere. Resource taxes may not be creditable against home country taxes, in which case they may serve to discourage investment in the host country. This may be important in designing the tax system to apply to resources.

A second institutional feature of resource taxation is that, in federal economies, jurisdiction over resources may be divided between two levels of government. For example, general taxes such as corporate taxes may be levied by the central level of government, while special resource taxes may be applied at a lower level of government. This complicates the tax system considerably.

Finally, resource exploitation may give rise to environmental costs of various sorts. These costs may be external to the resource firm itself. If so, special measures may have to be taken to ensure that the external costs imposed on the environment are taken into consideration by the firm in its decision-making.

II. THE GOALS OF RESOURCE TAXATION

As mentioned, governments typically tax resource industries over and above other industries, often with special taxes applying on resources alone. In this Section, we consider the reasons for this practice. The most important objective of resource taxation is to obtain some share of the rents for the public sector. We begin with a discussion of the concept of resource rents and then turn to a the reasons for taxing resources, one of which is to obtain a share of the rents for the public sector.

1. The Concept of Resource Rents

One of the key characteristics of natural resources is the fact that they generate *economic rents*. The rent of a stock of resource is simply its ultimate economic value, or the *economic profit* from its exploitation. More specifically, the flow of rent from a given amount of resource is the difference between the real accrued revenues it generates and all real accrued costs of obtaining those revenues. It is useful to distinguish non-renewable from renewable resource rents.

a. *Non-Renewable Resource Rents*

For a non-renewable resource such as a mine, the accrued revenues result from the final sale of the mineral to a user. The accrued costs include all the current and capital costs associated with exploring for the mineral, developing the mine site, extracting the ore, and processing it to obtain the mineral in usable form.

Revenues and current costs are conceptually quite easy to account for on an accrual basis. Revenues include the sale value of the resource when the transaction occurs independent of when cash actually changes hand. Accrued revenues will differ from cash receipts by accounts receivable. The same applies for current inputs. Their accrued costs differ from cash costs by accounts payable. The valuation of accrued revenues and costs should be at their value at the time of transaction rather than actual cash receipts or disbursements. These will differ typically by implicit interest costs. This makes exact measurement difficult.

Capital costs are even more difficult to impute since all capital expenditures must be appropriately capitalized. Thus, the cost of using depreciable assets includes three components — true depreciation of the asset, the real financial costs of holding the asset whether the financing be by debt or retained earnings or new equity, and any real capital losses resulting from changes in the replacement cost of holding the asset. All of these are difficult, if not impossible, to measure since they require one to know the true rate of depreciation of the asset. For a depletable asset, similar components should be included as costs, but in this case depreciation

is replaced by depletion of the asset through exploitation. Note that the acquisition cost of the depletable asset here includes the purchase price of any lease or property rights as well as exploration and development expenses. These must be capitalized appropriately as above. Any holding of inventories of goods in process or final product must also be accounted for on an accrual basis. The cost of using inventories includes the replacement cost of the inventory when used plus the real cost of holding the inventories including both financial and storage costs. Notice that if current inputs are used to produce inventories, they should not be treated as a cost until the inventory is used to produce revenues.

Finally, mining activities involve some risk and the full costs of risk-taking should be taken into account. There are various sorts of risk involved. In the exploration stage, there is the risk associated with not knowing what size of deposit will be found. There is a risk associated with future changes in the price of inputs (capital and labour) required to exploit the mine. And, there is the risk associated with uncertainty about the final price of the mineral when it is eventually sold. The measurement of the cost of risk-taking is not simple since it depends upon the extent to which risks can be pooled on capital markets. Thus, if capital markets were perfect, the only risk that need be a concern is the non-diversifiable risk associated with the mining activity. In principle, this component of risk may be observable as the *beta coefficient* in empirical capital asset pricing models.

b. *Renewable Resource Rents*

Similar principles apply to a renewable resource, though the emphasis will differ somewhat. Again, the economic rent from a renewable resource like a forest or a fishing ground will be the flow of accrued revenues less the flow of all accrued costs on a real basis. Accounting for revenues received and for current inputs used to produce revenues is similar to the case of non-renewable resources. Capital costs are somewhat different in nature. Any depreciable assets used in exploiting the renewable resource are treated as above. However, the asset associated with the renewable resource itself is quite different from a stock of non-renewable resource. Unlike with the former, there will typically be no exploration costs associated with discovering it. And, since it is renewable, it regenerates itself over time.

Consider a fishing ground as an example. The evolution of the stock of fish through time depends jointly upon the biological growth rate of the stock (which itself typically depends upon the stock) and the rate at which fish are taken from the fishing ground. There is usually no resource cost involved with this biological process (although fish farms may use restocking techniques). The opportunity cost of taking additional fish from the fishing ground at a point in time is the present value of the foregone flow of fish that results in the future. This is obviously a

difficult thing to account for. It presumes, for example, a particular pattern of behaviour into the future, ideally optimal behaviour. A similar accounting difficulty arises with a forest, except here there is the additional complication that costs of reforestation must be taken into account. As with the fishing ground, there is a natural growth rate of trees, so the stock of trees depends jointly upon the frequency of cutting and the growth pattern of the species of trees. Thus, the opportunity cost of additional cutting can be treated as the cost of replanting plus the present value of the change in the value of trees harvested into the future. Again, this is a difficult thing to measure. Finally, the property used for renewable resource exploitation may have an alternative use in which case that should be part of the opportunity cost of obtaining the resource. For example, in the case of a forest, the land may have a site value independent of its use for planting trees. The capitalized value of the land ought to be part of the ongoing cost of operating the forest.

The amount of rent that a given resource will generate depends upon the behaviour of the agent responsible for exploiting the resource. The agent's behaviour, in turn, depends upon the institutional setting, including the way in which property rights are defined, the efficiency of capital markets, and the tax or regulatory system in place. The basic presumption is that private sector operators will maximize the present value of after-tax economic profits (rents) over the applicable time horizon. If private ownership is absolute, the time horizon will be the indefinite future. We will refer to the value of rents generated by private optimizing behaviour as *private rents*. They may differ from *social rents*, which are the rents attainable from the resource from society's point of view. Private rents may differ from social rents for a variety of reasons. If taxes apply on the firm, they are part of the social return, but not of the private return. If the activities of the firm generates external costs, such as degradation of the environment, these will form part of social costs but not private costs. If the time horizon of the private sector is limited by institutional constraint, the measurement of rents from a private point of view will differ from that for society. Furthermore, potential social rents may well differ substantially from actual social rents generated by the exploitation of a resource. All of the above distortions can give rise to a pattern of exploitation which is sub-optimal from a social point of view. One of our purposes later on in this study is to consider with more precision how various taxes impinge upon the behaviour of resource managers.

Naturally, the amount of rent that can be generated from a renewable or non-renewable resource depends upon the features of the resource in question. Mines with higher quality ores will generate higher rents. Resources which are found in isolated locations will be costlier to exploit and will generate lower rents. Rents will also vary with the stock of a resource. For any given resource, we can think of there being a spectrum of low rent to high rent stocks ranging from negative to positive. Only those resource stocks with non-negative rents will be worth exploiting. Those resource stocks for which rents are zero will be referred to as *marginal resource*

stocks. Those with positive rents will be called *inframarginal.* The location of the marginal resource stock along the spectrum will also depend upon the institutional setting. For example, if the tax system impinges upon the marginal resource, it will make the after-tax rent negative and another resource deposit will become the marginal one. Much of our later analysis will consider precisely the issue of how the tax system affects the marginal resource stock.

We have noted a several points that the measurement of rents is a difficult thing, both conceptually and practically. This is because all accounting is on an accrual basis and in real terms, and many of the costs that must be imputed are not observable and therefore hard to measure. This would seem to make the concept of rents virtually impossible to use for any policy purposes and, as we shall see, that would be very unfortunate. The concept of rents as defined above is an economically attractive one since it measure the flow of the contribution the resource makes to real economic output at any point in time as an economist would see it. However, there is an alternative measure which gives the same present value of economic rents but a different time pattern. That is the *cash flow.* It consists simply of the difference between all cash receipts from the sale of output less cash expenditures for both current and capital inputs. Because capital costs are not capitalized, costs occur much earlier in time than under an accrual accounting system. Thus, the pattern of cash flows is typically lower earlier on and higher later than for economic profits. However, in present value terms, cash flow is the same as economic profits. It also has the advantage of being much easier to measure than economic profits since all items are, in principle, observable. There is no need to measure imputed costs, nor is there any need to index. The concept of cash flow will play an important part in our analysis of tax policy options and we discuss it in more detail below.

One final important property of the concept of economic rent should be mentioned before turning to tax issues. Since rent reflects the present value of the economic profits that a resource is expected to generate into the future, the value of the resource stock in question should be precisely the present value of its future rents. That is, future rents are said to be *capitalized* into the value of the resource. Because this is so, any tax changes that affect the value of rents in the future will be immediately capitalized into the current value of the resource. In that sense, current resource owners bear future expected resource taxes.

2. Reasons for Taxing Resource Industries

Given the different types of resource taxes used in practice, it is not surprising that there may be differing motives for taxing them. We present here a non-exhaustive list of some of the reasons for taxing resources in general and for the specific types of taxes sometimes used.

a. *Rent Collection*

The main justification for taxing resource firms is to obtain a share of the rents for the public sector. From a tax policy point of view, the taxation of rents is an ideal source of revenue since a rent tax is non-distorting (i.e., efficient) if designed properly. By definition, rents are the net value of the resource and do not represent the return to any variable factor of production. Since the objective of a firm will be to maximize the present value of rents, a proportional tax on rents will not affect the choices of the firm. Maximizing pre-tax rents will call for the same behaviour as maximizing a given proportion of pre-tax rents.

The equity properties of taxing rents are not as clearcut. For one thing, the ownership of rents are not necessarily correlated with a characteristic of taxpayers deemed worthy of special taxation on equity grounds. Furthermore, as mentioned above, taxes on rents can get capitalized into current values and thus effectively be incident on current owners. This is questionable on equity grounds.

b. *Capital Income Taxation*

It may be desirable to tax resource industries as part of the general taxation of capital income in an economy. In this case, capital income can be thought of as including both the normal return to capital plus rents. The task of taxing capital income falls jointly upon the corporate income tax and personal income taxation. In these systems, capital income on debt tends to be taxed primarily at the personal level. The corporate tax is usually levied on equity capital income, which includes rent. Special measures might be applied to resource industries as a way of ensuring that rents are included properly in the base.

c. *Industrial Policy*

The design of the tax system as it applies to resources may be chosen so as to achieve certain objectives of industrial policy such as the encouragement of further processing of resources or the maintenance of some minimum level of activity for strategic reasons. This is more often a reason for encouraging the activity through subsidization than the taxing of it to obtain revenues.

d. *Risk Pooling and Financing*

As mentioned earlier, taxation of resources can be analogous to the public sector becoming a silent partner in the firm. The deductibility of costs combined with the taxation of revenues is like the acquisition of new equity for the firm. This can be advantageous for the firm in a couple of ways if capital markets are imperfect. For one, if the government is better able to pool risks than the firm, the taxation of resource profits can encourage risk-taking and be socially beneficial. Also, the

taxation system can serve to improve cash flows in periods of expansion thereby assisting firms which have liquidity problems because of difficulties in obtaining outside finance. The effectiveness of the tax system for these purposes depends upon the firm being able to take full tax advantage of deductible costs. In the absence of full loss offsetting, that will not be the case.

e. *The Taxation of Foreigners*

If foreigners own resources in the country, the ability to extract tax revenues from them will provide an additional incentive for taxation. There are two sorts of circumstances in which taxes may be obtained from foreigners. The first is when the tax applies on rents, in which case the motivation is exactly as in a. above. The second is to exploit foreign tax crediting arrangements. If foreign governments offer tax credits on investments made abroad, it is in the interest of host countries to tax the firm up to the limit of the credit. This can significantly affect the design of the tax system and the level of taxation. In the absence of crediting arrangements, any attempt to tax capital income of foreigners will not succeed if the country is a price-taker in international capital markets. The tax will simply be shifted back to non-capital factors in the host country.

f. *Exercise Monopoly Powers in World Markets*

Some countries may be important enough suppliers of a resource on world markets that they are able to influence its price. One way of exploiting this power is to use tax policy. In this case, the appropriate tax would presumably be an export tax. Alternatively, public participation may serve to monopolize the sale of the resource directly.

g. *Conservation of Resources*

Finally, tax policy may be used as a way of inducing firms to tax account of external factors in their resource management decisions. Production taxes may be used to reduce the rate of exploitation of resources for social reasons. The latter may include environmental costs which depend upon the rate of extraction or equity concerns for future generations.

As mentioned, of all these reasons for taxing resources, that of capturing a share of rents for the public sector is by far the dominant one. The next section is devoted to issues arising from the attempt by the public sector to tax the rents accruing on natural resources.

III. PRINCIPLES OF TAXING RESOURCE RENTS

There is a large literature in public finance concerned with the design of a tax on pure profits or rents. Indeed, much of the theoretical literature on the corporate tax has addressed precisely that issue. Most of the analysis has concerned economic profits in general without specific reference to the resource industries, that is, without specifying the source of rents. A firm is simply assumed to have a decreasing returns to scale (i.e., strictly concave) production function involving a current input and a depreciable capital input. Part of the purpose of this section is to apply the results of this analysis explicitly to the resource industries where the rents arise because of a given amount of natural resource, renewable or otherwise. Although the general principles of taxing rents remain intact whatever the source of the rents, some special issues apply in the case of resources which affect the design of revenue-raising mechanisms. It is useful to begin with a discussion of some general issues that arise in the taxation of resource rents before turning to specific mechanisms.

1. Some General Issues

As we will see below, the principles of designing a proper rent tax in the ideal world often used by economists are fairly straightforward and can take a variety of alternative forms. However, in attempting to apply this in practice to the resource industries, several conceptual problems can arise. It is useful to begin with a list of some of these conceptual problems as a prelude to considering the various mechanisms.

a. *Ex Ante versus Ex Post Rent Taxation*

A stock of resources will yield a flow of rents over time. In the case of renewable resources, this flow can go on indefinitely, while for non-renewable resources the flows can only sum up to the given stock. Rent taxation can be designed so as to divert a share of the rents to the public sector from the private sector after they accrue. This is referred to as *ex post* rent taxation. On the other hand, as will be seen later, some rent tax mechanisms take a share of the rents before the rents actually accrue. This is *ex ante* rent taxation. In principle, *ex post* and *ex ante* rent taxation can be designed to yield equivalent revenues in present value terms, and part of the literature is devoted to ensuring that the base of the rent tax is equivalent in present value terms to the flow of accrued rents themselves. Economists have tended to view these taxes as having the same efficiency properties as actual rent taxes and have advocated their use. Some of them are attractive precisely because they are easier to implement than accrued rent taxes. The flip side of this is that whatever the rent tax collected, only its present value counts anyway since future

taxes should be capitalized into the value of the resource property.

However, the very fact that the public sector can apparently choose the time pattern of rent tax revenues gives rise to a couple of fundamental problems which are related to one another. The first is that governments can change tax rates at will over time as circumstances change. Thus, there will be some uncertainty about future tax liabilities on this account alone. In a sense, this would argue in favour of a tax base in which tax liabilities are incurred as up front as possible. Then, the consequence of possible tax changes later on will be less since the base will be lower then.

Related to this is the fact that there is a fundamental *time inconsistency* problem inherent in the taxation of natural resources. Once a resource property is acquired either through outright purchase of the rights to a known stock or by incurring exploration and development expenditures, governments have an incentive to tax the stock fully. If they could commit to a predetermined tax policy, they might choose a policy which induces the optimal amount of exploration, development and renewal. However, such commitment is not possible. Since private operators know that such commitment is impossible, they will adjust their behaviour in anticipation of future government tax policies. The result is inefficient behaviour. This seems to be an unavoidable problem.

It is one that also applies to foreign investors. If host governments could commit themselves to future policies, both taxation and expropriation, they could choose their policies to attract the most efficient level of foreign investment. However, once the foreign investment is in place, it becomes a fixed factor which is a good target for taxation. Foreign investors will anticipate this and act accordingly. The result will be a sub-optimal level of investment.

b. *Problems of Measuring Rents*

We have already made some reference to the fact that rents are virtually impossible to measure as they accrue. To do so requires being able to measure accrued real capital costs accurately, including real depreciation, real costs of financing, real capital losses, replacement cost of inventories, the cost of risk-bearing, etc. Special problems arise in the resource industries, both renewable and non-renewable. In the case of renewable resources, there may be costs associated with using the resource property for resource extraction as opposed to some other use (e.g., recreation, farming) and this must be accounted for. The cost associated with current extraction itself is a particularly difficult concept. In principle, the opportunity cost of increased current extraction is postponed future extraction. Given that the dynamics of extraction is itself liable to be rather complicated, this opportunity

cost is difficult to measure. Similarly, replenishment or renewal costs are difficult to measure on an accruals basis since they should be imputed to the period at which the resource is eventually extracted.

Similar problems arise with non-renewable resources. The costs of extraction are somewhat simpler to account for since they are simply the value of the resource currently extracted, it being no longer available for use. However, exploration and development costs should be capitalized as should any resource acquisition costs. This gives rise to problems not unlike the measurement of capital depreciation costs.

c. *Monitoring and Implementation Problems*

All tax systems are subject to enforcement problems, especially those administered on a self-assessment basis. Resource taxes would not be immune to this; in fact, such problems may be more severe in the resource industries if additional taxes are to be imposed. Problems can arise both through outright evasion or through avoidance. Evasion is an illegal activity which involves deliberately under-reporting tax liabilities. Given the fact that firms cannot be perfectly monitored, it is impossible to eliminate evasion entirely. Its incidence can be reduced by increasing resources devoted to auditing and by increasing the penalty for being detected. Of course, if administrative corruption is present, evasion becomes more difficult to control.

Avoidance refers to the reduction of tax liabilities by undertaking measures to divert revenues and costs among activities. Unlike with evasion, under-reporting is not involved. However, the means of reporting certain items may be affected. There are various ways of doing this. One is by the use of *transfer pricing*. Transfer pricing is a phenomenon that occurs primarily in vertically-integrated firms in which sales from one to another are not done at arm's length. Profits are diverted from high- to low-taxed firms or activities by changing the price that is charged in intra-firm transactions. Thus, if a resource firm is also involved in downstream processing, it may be able to avoid part of any special resource tax imposed upon it by arranging to sell its resource output to the processing firm at artificially reduced prices thereby taking more of its profit in the upstream firm. As well as shifting profits through transfer pricing, financial transactions can also be used. For example, if interest is deductible, firms can arrange to do their borrowing through the firm with the highest tax rate thereby reducing their overall tax burden. Again, resource firms may be particularly susceptible to these practices since they may face extra taxation. Finally, firms can rearrange their overhead and administrative costs by changes in marketing, head offices, research and development, and so on.

A final technique for avoiding taxes is to make masquerade profits as costs. This is a particular problem with cash flow types of taxes. Closely-held firms can

arrange to take some of their profits as salary payments thereby making their cash flows appear smaller and reducing taxes based on cash flows. This can be an issue in the design of taxes based on cash flows.

d. *Relation with Other Taxes*

Resource taxes will typically be part of a more general business tax system which includes corporation income taxation as well as personal taxation. The issue then arises as to whether one type of tax liability should be deducted against the tax base or credited against the tax liabilities of another. In the case of corporate and personal taxes, there is a strong argument in favour of integrating the two systems by giving some sort of credit at the personal level for taxes having been paid by corporations. This is usually done by means of a dividend tax credit administered at the personal level. This reflects the fact that the corporate tax is intended essentially as a withholding device against domestic tax liabilities for personal taxation. However, resource taxation is intended to be an additional source of tax burden over and above income taxation. Thus, crediting it, or even allowing a deduction for it against corporate taxes is not desired. Indeed, the opposite is the case. It can be argued that corporate taxes should be deducted against the resource tax base. If so, the rent tax would impose no further distortions over and above those already imposed by the corporate tax. Failing to allow a deduction would imply that the resource tax further compounds the distortion of the corporate tax. In fact, an efficient system would allow a full tax credit of the corporate tax against the resource tax. This would undo the distorting effect of the former. However, it would also undo the effect the corporate tax has on taxing capital income thereby defeating its purpose. Furthermore, it may undo the advantages of obtaining a foreign tax credit in the case of foreign firms.

e. *Absence of Loss Offsetting and Uncertainty*

Most tax systems, resource taxes included, do not offer full loss offsetting. At best they offer partial loss offsetting by allowing firms in a loss position to carry forward or backward losses for a limited number of years. Firms can be in a loss position for a number of reasons. They may be young, growing firms who are involved heavily in investment but whose revenues are expected to accrue only in the future. They may be firms who are temporarily in a loss position because of depressed output prices. Or, they may be declining firms. The absence of full loss offsetting is particularly harmful for the first two types of firms. These can be firms which are stretched for financing or which are in uncertain environments. Imperfect loss offsetting can exacerbate both problems.

Resource firms are typically relatively more likely to experience periods of loss. Since they are highly capital-intensive, they are typically in a loss position when young and growing. As well, their fortunes are likely to be much more uncertain since resource prices are known to fluctuate more than than for other products.

f. *Treatment of Foreign Income*

A final relevant general consideration is the fact that the resource business is typically an international one. That is, resource firms often operate in more than one country. This can have several implications for their tax treatment. For one thing, international operations open up opportunities for avoidance of the sort discussed earlier. This means that if one country's tax rates are out of line with those in others, it may be difficult to monitor and enforce tax collections. Also, international tax conventions will have a bearing on the tax treatment of resource firms Capital importing countries will need to take account of the home country tax treatment of foreign firms. For example, if home countries credit taxes paid abroad, which is often the case for business taxes, it is in the interest of the host country to take advantage of the credit by mimicking the home country's tax system. If such credits are not available, or if a deduction system is used, attempts to tax capital income of foreign firms will be frustrated. Because of the mobility of capital, the tax will end up being shifted back to other factors of production in the host country. On the other hand, if the tax is on the rent component of equity income, it need not be shifted. Indeed, it will not be except by the use of avoidance techniques. Typically resource tax systems will not be eligible for foreign tax crediting so will constitute an additional tax burden on foreign corporations. This will provide some incentive for tax avoidance measures.

Resource taxes, unlike income taxes are generally levied using the *source* principle rather than on a worldwide or residency basis. Each country treats as its own property rights some share of the the resource rents accruing within their boundaries. This is probably a necessary feature of resource tax regimes rather than being an abstract principle of the division of international property rights. It would be very difficult to monitor rents earned abroad by domestic firms.

Given this background of general issues, let us now turn to a consideration of some of the means by which resource rents can be taxed. In principle, the resource tax base could be defined as economic profits or rents of resource firms and a tax applied to that. However, as mentioned earlier, such a tax base would be virtually impossible to implement. It would involve imputing costs to the firm which are not directly observable including depreciation, depletion of non-renewable resources, the cost of current uses of renewable resources, risk, and the real cost of finance. Thus, from a practical point of view it is not feasible to tax rents as they accrue.

Fortunately, there are other ways of devising a tax base which are equivalent in present value terms. We begin with an outline of alternative equivalent measures of economic rents.

2. Some Equivalent Ways of Measuring Rents

It is useful to begin by recalling precisely what is included in the definition of economic rents in principle before turning to alternative equivalent measures.

a. *Economic Rents*

Current rents are defined to be the value of current output sold by the firm in the current period less the full opportunity cost incurred by the firm during the period to produce those outputs. The costs can be sub-divided into two categories — the costs of current inputs and the costs of capital inputs. Current inputs are those which are used in the period in which they are purchased. Capital inputs are those which produce services over several periods. Their contribution to each period must be appropriately capitalized. All costs must be measured in terms of a common numeraire, typically either current dollars or constant dollars. The fact that prices are changing over time gives rise to two complications. One concerns the price of capital goods and the other concerns the discount factor to use. These will be discussed below.

Current Inputs. Current inputs are typically taken to include such things as wages and salaries, materials, fuels, rents, and so forth. The classification of inputs as current is not without ambiguity. Some inputs which may appear as current may actually have a capital component to them. One example concerns labour costs. In many cases, labour once hired can be viewed as a *quasi-fixed factor.* Typically, there is a period of training involved early in the tenure of the worker. To the extent that the firm bears the cost of that training (e.g., if the training yields skills which are specific to the firm), part of the wage payment reflects not a payment for the production of current input, but for the production of future input. In this case, part of the wage represents a capital cost and should be capitalized. Also, the wage pattern may not follow the productivity pattern of the worker over the employment tenure of the worker. For example, the firm may use the wage profile to increase attachment to the firm essentially by postponing wage payments. Alternatively, the firm may act as a sort of financial intermediary to the worker by providing more funds in the form og higher wages earlier in the work life.. Finally, labor of the firm might also be used to produce and/or install tangible capital for the firm, such as buildings, machinery and inventory. That part of the wage bill ought to be treated as a capital input, though it is difficult to distinguish the amount of the

wage bill that goes for these purposes. For all these reasons, wage payments may not properly reflect current output. A true measure of profits would require wages to be appropriately adjusted. Of course, that would be very difficult to do, and to that extent rents will be incorrectly measured.

For closely-held businesses in which owners are also managers, another difficulty arises. The reward that the owner-manager receives for operating the business will be partly a return to capital and partly a return to labour. In practice, the two will be difficult to distinguish. This will be important if capital income and labour incomes are treated differently for tax purposes.

Another example concerns the acquisition of intangible capital by the firm, including goodwill and knowledge. Often this is a result of particular types of expenditures such as advertising and marketing. These costs should, in principle, also be capitalized, but are typically treated as if they were current costs. Again, to capitalize the costs of using intangible capital would be extremely difficult, if not impossible. This will be another source of inaccuracy in the measurement of rents.

These sorts of examples can occur in the resource industries as well. In non-renewable resources, exploration expenditures help to create information about the location and size of deposits. This is a form of intangible capital which ought, in principle, to be treated as such.

Capital Inputs. Even more difficult conceptual issues arise in the treatment of capital inputs. They yield productive output over more than the period in which they are acquired. The problem is to attribute to a period the full cost of using the capital. In principle there are three sorts of costs associated with the use of capital for a period:

i. Depreciation. We will use the term depreciation in a general sense to include all forms of using up capital including wear and tear of machinery and buildings, depletion of a stock of non-renewable resource, the use of an item from inventory, and the use of the existing stock of renewable resource. Some of these are more readily measured than others. For non-renewable resources and inventories, the current usage should simply be costed at the full value of the amount taken. These may be readily measurable using market values. In the case of depreciable capital, the reduction in the value of the capital due to depreciation through use should be treated as depreciation. Since full markets for depreciating capital typically do not exist, this is virtually impossible to measure precisely. For renewable resources, as we have mentioned earlier, the opportunity cost of taking some resource now is the change in the amount that may be taken in the future. This requires that the optimal path of fu-

ture extraction be known. In all cases, depreciation should be costed at its replacement value.

ii. Financing Costs. Holding a stock of capital of any kind for a period of time involves financing costs, either payments such as interest that must be made to creditors, or compensation for the use of one's own capital. The latter is the cost of equity capital and is the rate of return that is just required to compensate the owner for using his funds in this firm instead of placing them elsewhere. Thus, it is an opportunity cost which partly takes the form of a forgone return. The cost of equity financing for a given firm will consist of two components -- the market rate of return that could have been earned elsewhere plus the risk premium associated with this firm. The latter is difficult to measure. The financing cost should be based on the full replacement value of capital of all forms held by the firm. This includes the net value of accounts payable (i.e., accounts payable less accounts receivable). Furthermore, the cost of finance should be the real cost rather than the nominal cost. For example, the nominal interest rate will include a component which compensates creditors for the fall in the value of their asset due to inflation. As such, it represents a change in the principal rather than an interest cost. The nominal interest should be reduced by the rate of inflation, unless, of course, the asset is indexed for inflation.

iii. Capital Losses. Finally, if the relative price of a capital good falls over the period, that should also be treated as a cost of holding the capital. Of course, this term could either be positive or negative. If the price of a non-renewable resource in the ground rises, this reduces the cost of holding it, and vice versa. Indeed, in the theory of resource extraction, expected changes in price are a hey determinant of the decision as to how much to extract.

Capital costs should include each of the three items as appropriate for all forms of capital whether depreciable capital, land, inventories, non-renewable resource stocks or renewable resources. There should be no other deductions for these items. In particular, costs of acquiring the capital, including leases and property rights to resources should not be deducted. To do so would involve double-counting.

Present Value and Discounting. The above discussion concerns rents in the current period. Firms will typically operate for several periods and will take decisions from a long-term perspective. At a given point of time, what will be relevant is the present value of future rents rather than just current period rents. This should be what a profit-maximizing firm is interested in maximizing. There are several issues involved in measuring the present value of future rents. One concerns the time horizon itself. The typical practice is to take the time horizon as being the

indefinite future (i.e., infinity) if there is no reason to expect the firm to terminate operations before then. Even though the current owners will no longer be owners at some time in the future, they still have an interest in the subsequent operations of the firm since that determines the value for which they (or their estate) can sell the firm. A finite-time horizon will be relevant if, for some reason, the firm expects to cease operations. In the resource industry, a firm may expect the resources it holds to run out. Or, it may have acquired property rights for a fixed length of time only. Another reason for ceasing operations is the possibility of bankrupcy. In any case, in the event of ceasing operations, there must be an accounting of the disposal (scrap) value of assets on hand at the time. There may also be certain costs associated with shutting down, such as responsibility for disposing of hazardous waste in the case of mines.

Another issue is the choice of a discount factor. Assuming well-functioning capital markets, this should be the rate at which the shareholders of the firm are able to convert present into future consumption. Presumably this is some variant of the market interest rate. Note that there is no need to incorporate into the discount factor a risk component. This is already included as part of the cost of earning income in each period.

A final issue in discounting is the treatment of inflation. We have already noted that in accounting for depreciation, the replacement value for capital ought to be used, and the same applies for all forms of capital from inventory to non-renewable resources. That correction is intended to correct for changes in the relative value of capital. There is, in addition, the issue of how to treat changes in the general price level, or inflation. There are two alternative but equivalent procedures that can be used. One is to measure all revenues and costs in current dollars and to discount using a nominal interest rate. The other is to deflate all future prices to some constant dollar value, and discount them using a real discount rate. Note that this is quite separate from the use of a real interest rate for measuring the cost of finance. The latter should be done in any case.

We can summarize succinctly the present value of future rents (economic profits) for a representative special case in the following expression which ignores taxes:

$$\mathcal{R} = \sum_{t=0}^{\infty}(1+R)^{-t}\left(P_tY_t - W_tL_t - Q_t(\delta + R - \Delta Q_t/Q_t)K_t\right) \qquad (1)$$

where R is the discount rate of the firm, P_t is the price of output in period t, Y_t is the quantity of output sold, W_t is the price of the current input L_t, Q_t is the price of the capital good, δ is the depreciation rate, and K_t is the stock of capital. Note that all prices and rates of return are in nominal terms. It is assumed for illustrative purposes that the firm produces a single output using one current input

and one current output. It is also assumed that depreciation is a fixed proportion of the existing stock (i.e., exponential or declining balance), and that the nominal discount factor is fixed. Assume further that the inflation rate is constant at the rate π. Then (1) can be rewritten in the following equivalent form:

$$\mathcal{R} = \sum_{t=0}^{\infty}(1+r)^{-t}(p_t Y_t - w_t L_t - q_t(\delta + r - \Delta q_t/q_t)K_t) \qquad (2)$$

where r, p_t, w_t and q_t are real equivalents of their associated nominal values and are defined as: $(1+r)(1+\pi) = (1+R)$, $(1+p_t)(1+\pi)^t = (1+P_t)$, $(1+w_t)(1+\pi)^t = (1+W_t)$ and $(1+q_t)(1+\pi)^t = (1+Q_t)$. This illustrates the equivalence of using nominal prices and discounting by a nominal discount rate, and using real prices with a real discount rate.

b. *Cash Flow*

The above description of economic rents confirms that it is very difficult to measure rents. However, there are alternatives which have the same present value as rents but which are much easier to measure. As we have mentioned, one of these is the cash flow of the firm, which is simply the net value of all real transactions of the firm during a period. More specifically, the cash flow of the firm would include the cash receipts from sales of output less the full cost of purchases of all inputs, both capital and current. Revenues and current costs would all be accounted for on a cash basis rather than an accrual basis. So would all capital costs. The cost of capital installation would be deducted fully as the investment occurred. There is no need to account separately for depreciation, cost of finance and capital gains. The cost of inventory use would be deducted when the inventory was acquired rather than when it is used, and at the actual price of acquisition. There is thus no need to impute replacement costs or to worry about the cost of financing and capital gains. As well, the cost of acquiring resource properties including exploration, development, property rights, etc. would all be deducted up front as would the cost of intangibles. Thus, there would be generally no need to worry about either imputing costs which did not go through the market nor to index capital costs. Furthermore, there is no need to include the cost of risk-taking as a separate cost.

That is not to say that there would be no problems at all in measuring cash flows. There are still a couple of difficulties. One concerns owner-managed firms. These firms could arbitrarily reduce the values of their cash flows by paying profits out as salaries. As well, international companies could change their cash flows in various jurisdictions by means of transfer pricing. However, these difficulties already exist in the rent tax.

The present value of cash would be obtained by simply discounting rents at

the shareholders' discount rate. (Of course, there may be some ambiguity here as well since different shareholders may have different discount rates, say, due to different tax rates. Again, a similar problem also arises with discounting rents.) The important feature of the present value of cash flow for our purposes is that it should be exactly the same as the present value of rents. This can be illustrated using the same example as above.

The present value of cash flow is defined as:

$$C = \sum_{t=0}^{\infty}(1+r)^{-t}(p_tY_t - w_tL_t - q_tI_t) \tag{3}$$

where I_t is investment expenditures. To see the equivalence between (3) and (2), note first that the terms involving revenues and current costs are identical so we can concentrate on the capital costs. To make things as simple as possible to explain, suppose that the rate of increase in capital goods prices is constant at $\rho = \Delta q_t/q_t$. Then, the price of capital goods at time s is related to that at time $t < s$ as follows:

$$q_s = (1+\rho)^{s-t}q_t. \tag{4}$$

Consider the total amount of investment undertaken at time t, I_t. Given the depreciation rate δ, it gives rise to a stream of capital at each time s in the future equal to $(1+\delta)^{-(s-t)}I_t$. Using (4), the value of this stream of capital is given by

$$q_sK_s^t = \left(\frac{(1+\rho)}{(1+\delta)}\right)^{s-t} q_tI_t$$

where K_s^t is the amount of capital at time s that resulted from investment at time t. The total capital at time s is given by:

$$q_sK_s = \sum_{t=0}^{s}\left(\frac{(1+\rho)}{(1+\delta)}\right)^{s-t} q_tI_t. \tag{5}$$

Substitution of (5) into (2) and simplification yields (3). Intuitively, the present value of the future stream of accrued costs resulting from \$1 of investment is just \$i.

Thus, the present value of cash flow is equivalent to the present value of economic profits. Naturally, the time profile of the two will differ. It should be obvious that net cash flow is typically lower than rents in early periods and higher later on. This may cause difficulties for governments in attempting to tax cash flows, and it would be useful to seek ways of avoiding the problem. Fortunately, there exists an alternative to cash flows which has the same present value, which is almost as easy to implement and whose net value can take on any arbitrary time profile. We turn to that next.

c. *Cash-Flow Equivalent*

A very general tax base can be defined which has the same present value as rents and cash flows, and for which rents and cash flows are special cases. First of all, define an *accounting stock of capital* A_t implicitly in the following way:

$$\Delta A_t = Q_t I_t - \alpha_t A_t \tag{6}$$

where α_t is the proportion of the existing accounting stock of capital that is written off in period t. We will refer to α_t as the *tax depreciation rate* at time t. Note that it can vary over time. The idea is that all new investment increases the accounting stock of capital, while any tax depreciation reduces it. Thus, the accounting stock of capital is simply the aggregate of past undepreciated investment evaluated at historic cost (i.e., there is no inflation indexing imposed). The *cash-flow equivalent* income base is defined as:

$$P_t Y_t - W_t L_t - (R + \alpha_t) A_t.$$

The present value of the cash-flow equivalent income base is therefore:

$$\mathcal{E} = \sum_{t=0}^{\infty} (1+R)^{-t} \left(P_t Y_t - W_t L_t - (R + \alpha_t) A_t \right). \tag{7}$$

Several observations can be made about the cash-flow equivalent tax base. First, by a technique analogous to that used for cash flows, it can be shown that the value of $\mathcal{E}$ is equivalent both to $\mathcal{R}$ and to $\mathcal{C}$. The form of the cash flow-equivalent base is similar to that of the rent base except that capital costs are based on the accounting capital stock. Nominal deductions are given for the cost of finance of RA_t, and depreciation is also based on A_t. The rate of depreciation α_t is quite arbitrary. It can vary by size and over time as well. The higher is the depreciation rate, the lower will be the accounting stock of capital and the lower will be the cost of finance write-off. The cash-flow equivalent base would replicate rents if the depreciation rate were set equal to the *true economic depreciation rate*, that is, if $\alpha_t = \delta - \Delta Q_t / Q_t$. That can be seen directly. Of course, it is difficult to do so exactly since true depreciation cannot be observed. At the same time, the cash-flow equivalent base approaches cash flow as the depreciation rate approaches infinity.

In principle, the depreciation rate can be arbitrarily chosen. It can even be chosen by the firm. However, it might be natural to constrain the choice of α_t by the firm. For example, the firm might be tempted to choose α_t as high as possible to postpone tax liabilities. The government might then constrain the firm never to have a negative cash flow. If this constraint were imposed, the system would be exactly like a cash flow system with loss carry-forward at the interest rate R.

As mentioned, a useful property of the cash-flow equivalent tax base is its ease of implementation relative to true rents. There is no need to observe true depreciation. Nor is there any need to index for inflation. The depreciation rate used is completely arbitrary. It can be at different rates for different types of capital. It is even possible to treat current inputs as capital ones for this purpose. Similarly, all expenditures on resources can be included as forms of accounting capital and have a book value associated with them. It is always possible to lump together various types of expenditures into a single composite stock of capital for accounting purposes as long as they have the same tax depreciation rate.

In short, the theoretical literature tells us that it is relatively easy to devise an income measure which is equivalent in present value terms to rents. With this background, let us consider the sorts of mechanisms that have been used for taxing resources and compare them against the rent benchmark.

3. Rent-Maximizing Decision Rules

Equations (2), (3) and (7) all yield the same value. Any of them could be viewed as being he objective function for a profit-maximizing firm in the absence of taxes. Maximizing them will give rise to a stream of demands for current and capital inputs by the firm. It is worth at this point indicating the conditions that characterize the optimal choice of current and capital inputs in the absence of taxes so we can indicate later how taxes impinge on these decisions by the firm. To do so, we suppose that the quantity of output is determined by a production function $Y_t = F(L_t, K_t)$, and that the firm is a price-taker in all markets. Under these assumptions, the marginal conditions determining the choice of current inputs L_t and capital inputs K_t in each period are given by:

$$P_t F_{L_t} = W_t \tag{8}$$

$$P_t F_{K_t} = Q_t \left(\delta + R - \frac{\Delta Q_t}{Q_t} \right). \tag{9}$$

These equations state that inputs should be used up to the point at which marginal benefits equal marginal costs. The marginal benefit is the value of the marginal product given by the left-hand side of the two equations. The marginal cost of using the current input is simply its price per unit, W_t. For the capital input, the marginal cost is the right-hand side of equation (9), and is referred to as the *user cost of capital*. It consists of the three costs of holding capital: real depreciation, the cost of finance and the capital loss. Note that equations (8) and (9) can be rewritten in terms of real prices as follows:

$$p_t F_{L_t} = w_t \tag{8'}$$

$$p_t F_{K_t} = q_t \left(\delta + r - \frac{\Delta q_t}{q_t} \right). \qquad (9')$$

The above equation for capital costs is a general one that can be applied to all sorts of capital, although it is most directly applicable to depreciable capital. It is useful to recast it to apply to other types of capital specifically used in the resource industries. Three cases are considered — non-renewable resources, renewable resources and inventories.

a. *Non-Renewable Resources*

Consider the case in which a firm has a stock of non-renewable resource and has to choose the rate of extraction. Let the real price of a unit of the resource be p_t and the real marginal cost of extracting a unit of the resource be c_t. The stream of prices is given to the firm, but the marginal cost rises with the quantity extracted in each period. Then the optimality condition which determines the rate of extraction is given by the so-called *Hotelling Rule* which states:

$$\frac{\Delta(p - c')}{p - c'} = r.$$

The right-hand side gives the opportunity cost of holding the resource in the ground. The left-hand side gives the net rate of return from holding it. If the left-hand side is less than the right-hand side, the firm will want to increase its rate of extraction, causing its marginal cost to rise until the two sides come into equality, and vice versa. Of course, this is a very stylized way of looking at the extraction decision, but it does capture the fundamental forces at work.

b. *Renewable Resources*

As an illustration of a renewable resource, consider a stand of trees which is harvested using clear-cut techniques. Slightly different expressions will be obtained for other types of renewable resources, such as a fishing ground. However, the basic principles involved will be similar. Let $F(T)$ be the output of a forest whose trees are all of age T, and $R(F(T))$ is the net revenue from the cutting and sale of the trees. At the beginning of the planning period, suppose that a crop of trees is planted at a cost of C. Suppose the revenue function and the planting costs are unchanging over time for simplicity. The only decision that the forester must take is the age T at which to clearcut the forest and replant. This is referred to as the *rotation period.* The future operation of the forest consists of an indefinite number of cycles of planting and clearcutting each of length T. Thus, he incurs an initial cost of C, and then receives a sequence of net revenues of $R(F(T)) - c$ and T, $2T$, $3T$, and so on. Thus, the present value of the cash flows from the operation is:

$$\mathcal{V} = \frac{(R(F(T)) - c)(1+r)^{-T}}{1-(1+r)^{-T}}.$$

Choosing T to maximize this yields the following optimality condition:

$$\frac{\Delta R(F(T))}{R(F(T)) - c} = \frac{\ln(1+r)}{1-(1+r)^{-T}}.$$

This equation has basically the same form as that for the non-renewable resource. The left-hand side is the marginal value from increasing the rotation period while the right-hand side is the financial cost associated from the postponement in harvesting. The complicating feature is the fact that increasing the rotation period affects each and every rotation into the indefinite future.

c. *Inventories*

Suppose a firm has to decide how much of some good to hold as inventory. The good can be a final product or an intermediate one. Suppose the price of the good at time t is P_t. There may also be a storage cost of c_t per unit of inventory held. Then, the user cost of holding a unit of inventory consists of the cost of financing the inventory, any capital loss from holding it, and the storage cost. The holding of inventories presumably gives rise to some benefit to the firm. The benefit could involve cost reductions from production smoothing, or reductions is risk. Let us simply denote the marginal benefits from holding inventories as MB_t without specifying their source. Then the optimal stock of inventory holdings will be that at which:

$$MB_t = P_t \left(R + c_t - \frac{\Delta P_t}{P_t} \right).$$

Note that in this expression the user cost of inventories is evaluated at replacement cost rather than the cost at which any inventory holdings were originally acquired.

4. Mechanisms for Taxation of Resource Rents

The theoretical concept of rent, which is the primary basis of most resource taxes, is relatively clear. But the design and implementation of mechanisms for its taxation tends to be less than straightforward. In this section we deal with general types of such mechanisms and with some of the theoretical and practical difficulties involved in their implementation.

Mechanisms for rent collection differ in many respects. One of the fundamental distinctions is between *ex ante* and *ex post* rent taxation. *Ex ante* collection is based on the sale of the rights to the expected rents from a resource or a site, in the form of some sort of lease or concession arrangement. *Ex post* collection is some form of taxation that is based on the actual rents that are derived as the resource is exploited. One interesting question concerns the appropriate mix between *ex ante* and it ex post taxation of resource rents. In the following subsection we deal with the principal form of *ex ante* rent taxation — the sale of leases for the exploitation of a resource. The remaining sections deal with various means of taxing *ex post* resource rents.

a. *Auctions*

One way to capture the rent from a resource is to auction the rights to its exploitation. In *competitive* bidding for the right to extract and sell a given resource, a government should expect to be able to collect the full amount of the *ex ante* rent from that resource. This would include the present value of all revenues less all costs, including risk and a normal return to all investments, from its extraction; in other words, what we have called $\mathcal{R}$, $\mathcal{C}$ and $\mathcal{E}$ above suitably corrected for expected tax payments. This assumes, of course, that the government is willing to lease the resource-producing property for perpetuity, or at least for as long as the resource has any economic value.

There is a considerable literature on the properties of different types of auctions — sealed-bid first-price, sealed-bid second-price, Dutch, English, etc. While there are many important lessons from this literature, some of the most basic messages are quite simple. The first stresses the importance of competition in the bidding process. Without competition, there can be no assurance that the government will succeed in capturing a significant share of the rents. Competition might be difficult to achieve in many cases because of asymmetries in information about the size, quality, or other characteristics of the resource in question. This makes it even more important that the government not restrict participation in other ways.

The second is that under a set of reasonable assumptions, the above-mentioned four types of auctions all yield the same price on average. The assumptions include risk-neutral and symmetric bidders, the value of the item being bid for depending upon the characteristics of the bidders, and payment being a function of bids alone. As the number of bidders increases, the average revenue of the seller increases. As the number of bidders becomes indefinitely large (i.e., the competitive case), the price takes on its highest value. As mentioned, in the case of resources this would be the present value of rents. Of course, if the assumptions do not apply, the different types of auctions will not be equivalent. It would take us too far afield to consider the optimal types of auctions for different circumstances.

For our purposes, the important consideration is that given sufficient competition in the bidding process, the government should be able to capture virtually all of the *ex ante* or expected rents from the exploitation of any resource deposit. A perceived advantage to many governments from this way of collecting the rents is that the payment would be made up front, at the beginning of the extraction process. Only if the private sector and the government had different discount rates would this be of any real significance. If the government had a higher discount rate than the resource extracting firm (which might be the case with large transnational firms working in developing countries), then the pre-payment feature of an auction system might be of some benefit to the host government. If the opposite were the case, then any disadvantage to the government of the pre-payment feature (due to a lower bid price by potential developers) could be eliminated by an arrangement for postponement of payments.

One particular form of postponed payment system is an annual land rent for the use of the site on which the resource is located. Any once-and-for- all payment for the right to exploit a resource has an annual land rental fee to which it is equal in present value. Apart from the time pattern of payments, there are some other differences between land rental fees and pre-payment arrangements. First, the risk to the government is greater under the former arrangement. In the event that the resource turns out to be much less valuable than had been anticipated at the time of the rental agreement, the lessee would find it relatively easy to renege on the agreement by simply ceasing to pay the rent. There is little the government could do to prevent this. Second, under an annual rental arrangement, the lessee would have an incentive to exploit the resource more quickly than under a pre-payment system, given the positive marginal cost of exploiting the deposit for one additional year. This might also lead to under-exploitation of the resource since marginally economical deposits might not be financially attractive to extract if this requires extra time and hence additional rental payments at the end of a lease.

Ex ante rents, of course, are not the same as *ex post* rents. An auction system, as opposed to most other systems discussed below, captures the former. Therefore, auction systems differ from most other forms of resource taxation in that they shift the burden of risk from resource exploitation onto the developers. To the extent that social risk is less than the private risk of the developers, this lends some inefficiency to auction systems as a means of collecting resource rents for the public sector.

A lease auction could be transformed into a partial or full *ex post* payment system by making the bids somehow contingent on the value or quantity of the resource actually extracted. For instance, lease payments could be of the form $R = a + bY$ where Y is the value or volume of resources retrieved and sold from the deposit. The standard pure *ex ante* auction system is one in which b is set equal to zero and competitors bid on a. An alternative, however, would be for a to be

set equal to zero and to have potential leaseholders bid on b. This would be a pure royalty system in which the royalty rate is set by a competitive bidding process. A mixed system would be one in which the government entertained bids on both a and b, or in which it set a fixed positive value of one of these parameters and asked for bids on the other.

Auction systems also expose private resource developers to another potentially important form of political risk arising from time inconsistent behavior on the part of the government. Having conducted an auction and collected substantial if not complete pre-payment of the negotiated lease price, the government might be tempted at some later date to alter the terms of the original lease. Such changes might range from breaking of the lease altogether (i.e. confiscating the previously negotiated exploitation rights) to the imposition of windfall income taxes when *ex post* rents turn out to be greater than *ex ante* rents. In a world of fluctuating resource prices the imposition of such windfall taxes based on short-term rents would turn out to be a one-sided bet in favour of the government. Anticipation of this sort of political risk would reduce the ability of the government to collect *ex ante* rents. Of course, an anticipated willingness of the government to entertain short-term rent-based arguments made by lease-holders in times of low resource prices would work in the opposite direction.

In order for the government to maximize the proportion of the rents it is able to collect from an auction system, it is important that all the terms of the lease be specified as clearly and irrevocably as possible at the beginning. This applies especially to the conditions under which the lease might be altered or terminated, the nature of tax and other obligations expected of the developer throughout the term of the lease, and the means through which any future disputes over these matters might be settled. Regardless of the tightness of all such arrangements, reputation effects, based on actual behaviour of the host and possibly of other governments will be important in determining their effectiveness. It is probably because of this moral hazard problem, together with the general unwillingness of governments to enter into long-term lease arrangements with private resource developers, that auctions and other forms of *ex ante* rent collection agreements are seldom observed as methods of taxing economic rents in developing countries.

Resource rents can also be lost through inappropriate provision in long-term leases for external effects of the exploitation activity, such as environmental pollution. These external effects might be an ongoing byproduct of the developer's extraction activities and/or they might be long-term costs that are imposed and felt primarily after the conclusion of the project. The latter might be especially important in conjunction with leases whose lives do not match the economic lives of the resource deposits, particularly in the case of renewable resources. Mine sites might be left in a hazardous state after the expiry of a mining operation.

Forest reserves might be "mined" with inadequate investment in to replenishment and/or replanting. A short-run revenue-maximizing view would be to collect all the "rents" that are possible without taking these costs into account. Such an approach might be favoured by both short-run revenue-maximizing governments and profit-maximizing resource operators. Permitting mineral operators to mine a site without any restrictions on its condition at the conclusion of the operation would permit the government to maximize the bid it would receive for the rental of that site. But after account had been taken of the costs of site clean up after the operator's departure, the net rents received by the government would almost certainly be less than those that would have been collected if the bids had been made with the understanding (and the incentive) that the operator would be responsible for the appropriate environmental management of the site. Similarly, a lease for a forest concession might bring in much more money to the government if there were no incentives or requirements for the concessionaire to invest in the long-run management of the reserve. But, once again, this would not be equivalent to maximizing the rent from the resource. Government revenues would have been maximized at the sacrifice of long term rents and efficient resource utilization.

b. *Cash Flow and Equivalent Cash Flow Taxation*

In our review of the concept of resource rent and its measurement we showed how the present value of the net cash flows of a resource firm is equivalent to the present value of the rents from its activities. From this it follows that a tax equal to $x\%$ of a resource developer's cash flow would be equivalent to an $x\%$ rent tax and, in the absence of capital market imperfections, would not distort the efficient allocation of resources in the market. Furthermore, if the tax rate were 100%, it would be equivalent to the outcome of a competitive bidding process for resource extraction rights except for the fact that the cash flow tax would be an efficient collector of *ex post* rents, while an auction system would do the same for *ex ante* rents. A cash flow tax shifts all the risks over actual rent manifestations to the government, whereas a lease auction places these risks on the resource developer.

The equivalence between a 100% cash flow tax and a competitive lease auction depends as well on several critical details of implementation. The most important of these is the treatment of tax losses. Most resource ventures have the characteristic that cash flows are negative in early years and positive later. In order for a cash flow tax to be equivalent to a pure rent tax, negative cash flows must be a) subject to immediate refundable tax credits, or b) permitted to be written off against current taxable income from other sources, or c) allowed to be carried forward with interest at prevailing nominal market rates. Without such provisions, the base of a cash flow tax would exceed, in present value terms, that of a pure rent tax for a loss firm. Such a tax (i.e. without these provisions for tax losses) would no longer be non-distortionary; it would discriminate against investments with relatively long

gestation periods and those undertaken in periods of relatively high nominal interest rates. It would also discriminate against young, growing firms at the expense of older established ones. And, it would discriminate against risky investments and in favour of safe ones. Solving this problem with alternative b), i.e. write-offs of tax losses against other current income sources, would bias the tax system in favor of large established firms and against new ventures without other income sources.

Cash flow taxes are relatively uncommon. Instead, many governments impose taxes on bases which are, in principle, intended to be equivalent (again in present value terms) to that of a cash flow tax. As demonstrated in the previous section, a tax on current net revenues less capital cost allowances equal to the sum of economic depreciation, interest costs on current capital stock and capital losses during the current period would be equivalent to the same tax levied on current cash flows. The difference between this and a cash flow tax base is in the treatment of capital costs. Instead of being written off at the time of their expenditure, capital costs are amortized and deducted from revenues according to their current user cost. This method tends to smooth out the time path of taxable income for the firm and, in particular, to make it more likely that there will be current revenues against which to write off tax-deductible costs that occur in any time period. However, to the extent that discrepancies still do arise between current revenues and allowable costs, appropriate methods must still be found for carrying forward or backward costs which are in excess of taxable revenues in any time period.

The principal problem that arises with cash flow equivalent taxes is in devising rules for defining the user cost of capital. This is especially so in the case of resource taxation. There are not only the standard difficulties of defining appropriate economic depreciation rates and rules for deductibility of interest expenses, but also those of determining the appropriate treatment of exploration expenses, "depletion" allowances and expenses incurred in the maintenance and management of renewable resources. The principal danger in the case of non-renewable resources is that of dissipating the tax base by allowing excessive deductions for exploration and depletion (as is often the case with the use of generous depreciation allowances and/or investment tax credits with the normal corporate tax). For example, firms are often allowed a separate deduction for depletion over and above being able to write off many of the costs of acquiring a resource property up front. This obviously involves double-counting. In the case of renewable resources, such as forests, the more prevalent problem is that of overestimating rents by not allowing proper deductions for replenishment costs. Deviations such as these from a pure rent tax will not only affect the tax base but also distort investment decisions in resource exploration, management and extraction. We have outlined a general method above for designing a tax system which will have the property that it is equivalent to rent taxation. To date, no countries have taken advantage of it.

Another type of cash flow equivalent tax that is sometimes used in resource industries is a "rate of return" tax or a tax on "added value." The purpose of this sort of tax is to avoid many of the ambiguities and arbitrariness of attempting to measure the user cost of capital by a more certain and uniform measure. The measure employed for this purpose is simply the replacement cost of the current capital stock of the firm times the current market rate of interest. While this avoids some of the arbitrary distinctions that might occur because of differences in debt-equity ratios and differences in historical values of investments combined with the effects of ad hoc depreciation rules, it still faces important problems in the measurement of the replacement value of the current capital stock. The problems of determining economic depreciation and of valuing the firm's investments remain, albeit in a slightly different form.

c. *Royalties*

Another very commonly used form of tax for diverting rents to the public sector is a royalty or severance tax levied on resource extractions. A system of royalty payments could be equivalent to a pure *ex post* rent tax if the royalty were designed in such a way that it were equal or otherwise proportional to the economic rents associated with the amounts extracted. This would require that it be based on the value of the extractions less all the economic costs associated with them. Very few royalty systems meet this requirement. A per unit royalty system takes account of neither the value of the resources sold nor the cost of their extraction. A per unit royalty where the size of the payment depends on the grade or quality of the resource extracted as well as its quality goes part of the way towards the solution of the first of these problems, but does not deal with the second. An ad valorem system based on the gross market value of resource production deals more satisfactorily with the first problem, but still does not help with the second. Ad valorem systems based on net revenues generally consider, at best, only current costs of resource extraction and hence still overestimate true economic rents in the tax base. The extent of the bias depends on the importance of capital costs in total costs.

Some royalties discriminate on the basis of the final use to which the resource is being put. The most common levy of this sort is an export tax on resource products. Such export taxes differ from pure rent taxes not only by generally ignoring extraction costs in defining the base, but also by exempting resources which are sold in the domestic market. The usual reason for this form of tax is to subsidize domestic users of the resource product. As mentioned earlier, this practice usually is associated with industrial policy goals of promoting downstream processing industries. A commonly used tax structure in this regard is one in which the export tax rate is negatively related to the extent of domestic value-added in processing activities. Whatever the justification for this sort of tax, it is clear that it diverges considerably from a tax on economic rents.

Royalties, therefore, tend to be very imperfect mechanisms for the taxation of resource rents. We postpone to the following section a discussion of some of the adverse incentive effects arising from the use of imperfect rent taxes such as these.

d. *Production Sharing and Public Sector Equity Participation*

Many governments attempt to tax resource rents through some form of more direct participation in resource exploitation. Two of the most common methods are production sharing and equity participation.

The simplest form of production sharing arrangement is one in which the government receives a certain proportion of the output or of the sales revenue from a resource deposit that they have leased to an operator. This is just like a type of crop-sharing which is commonly observed in agricultural production. It is formally identical to a crude (ad valorem) royalty described in the previous subsection and is a very imperfect rent tax. As with royalties, more complex production sharing agreements can be devised in order to correct for the obvious distortions of the crude form. For instance, a fixed amount of the initial production might be reserved for the developer in order to compensate for capital and exploration costs. Only after that initial amount would production sharing with the government begin. Of course, the extent to which this actually covered or exceeded capital costs would depend on the price of the resource at the time it was extracted. And the extent to which the production shares corresponded to economic rents (after capital costs) would depend on the value of the developer's share relative to current extraction costs. In order to properly reflect economic rents, the production shares would have to vary with the price of the resource and the actual value of current extraction costs. The latter would vary across resource deposits and over time with any given deposit. Production sharing agreements, therefore, will be generally a very poor substitute for taxes on resource rents.

Another form of direct government participation is through the purchase or granting of equity in a resource extraction operation. The extent to which such arrangements substitute for a tax on resource rents will depend on the terms under which the equity is acquired. Suppose the equity is acquired through governments contributing to the operation's capital investment in return for an equal share of the flow of net current revenues from the resource extraction operation. Then the returns that will accrue to the government could be thought of as comprising two parts: a) its share of the returns to capital investment, and b) an equal share of the resource rents. 100% government ownership would correspond to a 100% rent tax, 50% ownership would be equivalent to a 50% rent tax, and so on. The coexistence of other forms of income and resource taxes on such joint venture firms would complicate this simple relationship.

Of course, if the price the government pays for equity participation exceeds its share of the capital investment of the firm, then it will end up collecting a smaller proportion of the rents by this method. In particular, if the equity price were the same as what would be paid by a new private investor, and hence included the capitalized value of expected rents, then no (*ex ante*) rents at all would accrue to the government through its equity ownership. Any rents that were collected would arise only because of differences between actual and expected rents. These could be positive or negative.

Suppose, as is sometimes the case, that the government equity is obtained free of charge, i.e. without any contribution to the firm's capital. This free equity could be thought of as payment by the firm for the rights to resource extraction. If the equity share were on the same terms as if the government had invested — i.e. it gave the rights to a certain proportion of the flow of net current revenues of the firm — then this would be equivalent to a tax on both resource rents and private returns to capital. The only way to convert this into a pure rent tax would be to deduct from the government's revenue rights an imputed return to the firm's capital investment.

There are several other differences worth noting between such equity or joint venturing schemes and pure rent taxes. First, government participation is sometimes seen to have additional advantages to other forms of rent taxes by giving the government some voting power and hence direct control over the firm's activities and by giving the government "a window" which provides valuable information pertinent to both taxation and other forms of regulation of the resource sector. Second, it cannot be automatically assumed that revenues accruing to government resource companies are equivalent to tax revenues paid directly to the state treasury. Because of their greater independence from traditional government budgetary agencies, resource-rich state companies are notorious for the many ways in which their spending patterns differ from those of these other agencies. In many circumstances it is most realistic to treat state resource firms' profits just like those of other private companies. Then state ownership makes no contribution to the government's efforts at rent taxation. In fact, the taxation of state companies is often more problematic than it is for private companies.

IV. THE COSTS OF IMPERFECT RENT TAXES

1. Introduction

Most taxes are levied on proxies or imperfect substitutes for the bases at which they really are directed. This certainly tends to be true of those on economic rents from the exploitation and sale of resources. This has implications both for government revenues and for the allocation of a country's scarce resources (natural and other). A pure rent tax can be levied at rates of up to 100% without reducing the efficiency of resource allocation. However, if the tax base diverges from true economic rent, then any tax on that base will affect investment and other allocation decisions of private agents and cause inefficiencies in these decisions when viewed from the vantage point of aggregate economic welfare. The nature and extent of these inefficiencies will depend on the form of the divergence of the tax base from true economic rent. But in general the size of the efficiency cost will depend, among other things, on the rate of tax, or, more precisely, on the square of the tax rate. As long as tax revenues are increasing in the tax rate, there will then be a trade-off between government revenues and efficiency of resource allocation. This is not true of a pure rent tax. In a world of imperfect taxes, therefore, it is important to understand the nature and the costs of inefficiencies arising from different methods of taxing resource rents. This will facilitate the design of tax systems that will best promote the government's revenue goals while minimizing the efficiency costs imposed on the economy. The ideal tax system from this viewpoint might be expected to differ across countries and even within countries depending on the mix of resource products and the specific circumstances of their exploitation.

Most countries do use a wide variety of mechanisms for taxing resource rents. Royalty formulas might differ considerably across resource products. Partially or completely pre-paid leasing arrangements might be used in some sectors and not in others. The same is true of government participation through production sharing and/or equity ownership. Arrangements sometimes differ across firms within the same industry. Furthermore, it is the norm rather than the exception for the same activity to be subject to a number of different types of taxes and royalties. Many of these differences in and mixtures of taxes are due to historical accidents and other reasons that have little or nothing to do with the design of an efficient or otherwise appropriate tax system. Nevertheless, the number of varieties and combinations of taxes that are possible for the collection of economic rents suggest the importance of understanding some of these incentive effects and the determinants of their significance as a guide to the design of resource taxation systems. The purpose of this section is to provide some insights into these questions. An exhaustive treatment of all these possibilities would be almost impossible and not particularly useful. The alternative that we attempt here is to provide some general principles for the understanding of these issues and some illustrations of some interesting types of

cases.

Our perspective is generally that of looking at divergences from neutrality in taxation. In the absence of other distortions from economic efficiency, a neutral tax system will also be efficient. When a particular resource extraction activity involves significant externalities, then offsetting non-neutralities in the tax treatment of that activity might be appropriate. Of course, other types of regulation or institutional innovation might be much more effective and less costly means of achieving the same goals. In these cases, it is still important to understand the nature of the distortions that result from different types of taxes. Without such knowledge the design of appropriate non-neutral tax treatment of that activity would not be possible; nor would a comparison of this with other forms of regulation.

2. Decisions Affected by Rent Taxes

Resource exploitation involves a number of different types of activities. In the case of non-renewable resources these range from exploration to extraction to processing to marketing. Renewable resources involve all of these types of activities as well as those related to the long-term management and replenishment of the resource. Taxes and other regulations might even determine whether a resource is renewable or non- renewable. The tax system can affect decisions at all points in the production process. The decisions which are affected at any stage might involve the level of the activity in question, the input mix and/or the technology utilized, the disposal of the outputs (marketed and non-marketed), and the timing of the activity. In the remaining sections of this chapter we discuss some of these effects in relation to different types of resource taxes and illustrate a method by which one can measure their quantitative importance.

3. Royalty Structures

Even the best designed royalty systems are very imperfect proxies for taxes on economic rent. Their basic difficulty is that they ignore all capital costs involved in resource exploitation. In many cases they also ignore at least some components of current costs and/or imperfectly account for them. This means that royalties generally tend to overestimate economic rents, with the extent of the divergence depending on the importance of the underestimated and/or ignored elements of costs. This will discourage at least some resource-related investments. At low rates of tax this might not discourage many socially desirable resource exploitation activities. But at higher rates of tax that might be necessary to collect significant public revenues, considerable amounts of such desirable investments might be discouraged.

Consider first the effect of ignoring capital costs in the definition of the tax

base. The general effect of this defect in defining the base is to bias the tax system against capital-intensive resource investments. Consider two resource projects, both of which have the same net present value of cash flows over their lifetime, but one of which has a much higher level of capital costs which are offset by higher sales revenues at the time of marketing the product. The more capital-intensive of these projects would be subject to much higher royalty payments over its lifetime than the other. Despite the fact that the projects are equally socially desirable (from the efficiency viewpoint), the more capital-intensive project would be much less likely to be undertaken. The royalty system creates a distortion by driving a wedge between the returns of marginal investments of different capital intensities.

In the case of non-renewable resources, for instance, this would discourage projects with relatively high exploration costs. With renewable resources, this would create a distortion against projects with high replenishment costs. It would bias forest activities in favor of mining of the natural forest and against cutting programs involving significant silvicultural management or the development of plantation forests.

The non-deductibility of capital costs is especially harmful when the effects of the royalty system are considered in conjunction with those of corporate taxes. The treatment of capital costs in royalty systems means that royalties are taxes not only on economic rents, but also on capital income derived from resource exploitation activities. Corporate taxes are also levies on capital income. The combined effect of these two different taxes, therefore, is double taxation of capital income. Relative to other sectors, therefore, the imposition of royalty payments discourages investment in resource projects.

The effects of the mismeasurement of elements of current costs in a royalty system can be thought of in a similar fashion. First, the exclusion of current costs, as is done in the crudest form of royalty system, also overestimates rents and, at least at high rates of tax, discourages socially desirable resource exploitation projects. Second, such systems create a distortion against projects which are relatively intensive in the use of current inputs which are excluded from consideration in the base. Consider two projects or activities of the same pre-tax net present value and which are similar in every other respect except that one is more intensive in some current input whose costs are not taken into account in calculating the base of the royalty. Because the costs of that input cannot be deducted from the tax base, this project or activity will be subject to higher royalty payments, and hence will be disfavoured by the tax system.

The most common manifestation of this sort of distortion is the phenomenon known as "high grading" of a resource deposit. In the presence of a royalty system which provides a fixed (possibly zero) allowance for current costs in determination

of royalty payments, developers will extract only those resources with relatively high values and/or low costs and ignore high-cost and/or low-value deposits or parts of deposits that still have positive social value. Despite their positive social value, the royalty system discourages their extraction by charging a tax in excess of the net current revenues from their extraction. Such systems encourage forest concessionaires to cut only the high-value stems in a stand and leave behind and often even damage or destroy smaller stems of significant social value. Similarly, mining operators are encouraged to close down mines before all socially valuable deposits have been extracted.

4. Export Taxes

An export tax bears a close resemblance to a crude royalty and has all of the same efficiency costs. In addition, it discriminates between resources marketed domestically and those sold in the world market. If a resource has no outlet in the domestic market, there is no additional efficiency cost due to this form of discrimination. However, this is seldom the case. When resources can be sold in the local market, an export tax induces them to be sold at a lower tax there than in export markets. Rents become dissipated by selling the resources at below world market prices to domestic users. The loss of government revenues arising from the use of an export tax rather than an equivalent royalty on all sales, export and domestic, is proportional to the size of the domestic market. The efficiency cost depends on the size of the tax and on the elasticity of domestic demand.

The only case in which this efficiency argument against export taxes might not apply is when the country is sufficiently large in the world market for the resource in question that it has some monopoly power in that market. In this case there is an optimal export tax which is inversely related to the elasticity of world excess demand for the product. A general observation that is relevant here is that world markets for most resource products generally tend to be much more elastic than is claimed by the proponents of optimal export taxes. This is especially true in the longer run when other sources of supply become available and users are able to adapt to higher prices through various forms of substitution. The second observation is that an optimal export tax is not a substitute for other taxes to collect economic rents. An ideal export tax facilitates the collection only of the rents arising from a country's monopoly position in world markets. The rents arising from differences between the competitive price of a resource and the costs of its extraction are left untouched by an optimal export tax.

A common reason for using an export tax rather than a uniform royalty is to promote the development of downstream processing industries. An export tax gives domestic processors access to the raw material at a price that is less than that faced

by foreign processors, with the gap equal not only to the cost of transporting the resource to the foreign plant, but also the size of the export tax. The amount of the subsidy provided to domestic users depends on the rate of the export tax and on the importance of the resource in total processing costs. This form of subsidy gives rise to several types of inefficiencies. First, to the extent that this effective protection is actually necessary to encourage domestic processing by marginal firms, it substitutes high cost ways of earning or saving foreign exchange (exporting locally processed raw materials) for lower cost ways of doing the same thing (exporting the unprocessed resource). Resource rents and government revenues, in effect, are dissipated in the subsidization of inefficient marginal domestic producers. Second, by artificially lowering the domestic cost of natural resource inputs, export taxes induce local producers to be wasteful in the use of these raw materials. Plywood and saw mills in countries with significant export restrictions on logs, for instance, tend to have much lower log recovery rates than do mills in log importing countries.

5. Concessions and Leasing Arrangements

The leasing of concessions to a natural resource deposit can yield revenues which are identical to the ex ante rent from that resource. As mentioned earlier, however, it is important that the length of the lease correspond to the useful life of the deposit. Most governments are reluctant to enter into sufficiently long-term leases for this purpose. This generally means that lease revenues will be less than what could have been collected otherwise.

In the case of non-renewable resources, the short term of the lease makes it difficult for operators to extract all the usable resources from the project. This leads them to offer a lower bid for the concession. It also induces them to engage in inefficient mining practices aimed at speeding up the extraction process. This generally reduces the value of the deposit to potential future operators. Even if the current operators have a right of first refusal on future leases, political and other uncertainties will cause them to discount this possibility and to shorten their time horizons in planning current activities. Therefore, short-term leases, even when offered consecutively, will generally yield less revenues than long term leases for non-renewable resource deposits.

The same will generally be true in the case of renewable resources. However, in this case short-term leases might yield much greater revenues over the early years of exploitation than would be obtained from perpetual leases. The reason is that short-term leases give the operator very little incentive to engage in investments in replenishment or renewal of the resource. In these circumstances, the operator would simply mine the first generation or rotation of the resource stock (assuming that this was the length of the lease) without regard for the consequences for future

generations or rotations. Therefore, short-term "rents" might be much greater than with a long-term lease holder, and renters might be willing to pay quite high prices for short-term leases. But, of course, what appear as rents to the short-term lease holder are largely postponed investments in replenishment and/or the destruction of much of the potential for longer term rents. The present value of the future stream of all rents that could be received would certainly be less with a succession of short-term leases than with one perpetual lease in the presence of these sorts of incentives. The burden on other types of regulation of lease-holder behavior is very great when leases for renewable resources are relatively short.

6. Measuring the Distorting Effect of Taxes

Up to now our discussion of the effect of resource taxes has been largely qualitative in nature. For some purposes it may be desired to obtain quantitative measures of the extent to which different tax instruments distort decisions. A conventional tool for doing so is the use of *marginal effective tax rates.* These were initially devised as ways of measuring the size of the distortion imposed by capital income taxes on the decision to invest in depreciable capital. However, they can be used to tax wedge imposed on virtually any capital decision, and have been applied to such things as inventory holding and non-renewable resource exploitation. Since the methodology for calculating marginal effective tax rates is somewhat technical, we have relegated it to an Appendix. It can be omitted without loss of continuity. In the Appendix, we illustrate the use of marginal effective tax rates in the non-renewable resource context, concentrating on capital investment and extraction decisions. We do so for fairly simple example, ignoring such important complications as risk and the absence of full loss offsetting.

V. POLICY IMPLICATIONS

1. Introduction

We conclude this review by summarizing some of its implications for resource tax policy. It is useful to begin by briefly recalling the role of resource taxes and their place in the system of taxes. Resource taxes are part of the overall system of taxes which impinge upon the incomes of businesses. The system usually includes direct taxes of a general nature such as the corporation income tax and taxes on personal and unincorporated business income, indirect taxes of various sorts including sales and excise taxes as well as export and import duties, and taxes specifically designed for resource industries.

The system of income taxes is intended to tax capital and personal income of residents and, where possible, of non-residents earning income in the country of taxation. Such systems typically include both a personal tax system and a corporate tax system. The corporate tax system ought to be viewed as supplementary to the personal tax, that is, as a withholding tax on capital income earned in corporations. It essentially ensures that equity income earned in the corporation is taxed as it is earned, whether or not it is distributed. Many countries recognize this withholding role by integrating the corporate tax with the personal tax system through the use of measures such as dividend tax credits or dividend paid deductions from the corporate tax base. This essentially ensures that double taxation of equity income is mitigated. In the case of foreign corporations, the corporate tax also facilitates a tax transfer from foreign treasuries in cases in which foreign governments offer foreign tax credits. Host country tax systems are often (or should be) designed with this in mind. Interest income tends to be taxed at the personal level since withholding is not necessary here. Income taxes, if designed properly, tax all capital income on a uniform basis, including both the normal return to capital and any rents. Of course, the design of many tax systems is imperfect in the sense that this uniformity is not achieved.

One of the ways in which non-uniformity is evident is in the treatment of resource industries. In most countries the capital income tax system treats resource industries quite favourably relative to other industries. This occurs mainly because of the favourable treatment afforded various capital expenses which are specific to the resource industries. For example, some items of a capital nature are given rapid write offs in tax systems which are meant to be abiding by the accrual method of accounting. These include the costs of acquiring resource properties and exploration and development expenditures. Furthermore, double write-offs are often given by virtue of deletion allowances for resources used up. And many developing countries have traditionally given generous incentives in the form of tax holidays, investment tax credits, duty exemptions on imported equipment, and valuable loss carry for-

ward provisions. The consequence is that equity income in the resource industries is often undertaxed relative to other industries. Some corporate tax systems also allow deductions for resource taxes paid. To the extent that this is the case, it vitiates the effect of the resource tax. To the extent that it is desirable to supplement general income taxes with resource taxes, this is undesirable.

The case for special resource taxes is precisely to tax resource rents over and above the levies that are implicit in general income taxes. There are two sorts of arguments for this. One is the efficiency-based argument that resource rents are non-distorting and therefore are an ideal source of revenue from an efficiency point of view. The other one, which is complementary, is that the property rights to resources ought to accrue to the public at large rather than to private citizens since they represent the bounties nature has bestowed on the economy rather than a reward for economic effort of some sort. This can be viewed as a sort of equity argument. However, one must be careful in applying it. In an economy with no resource taxes, the value of known stocks of resources will be capitalized into existing property values at least to some extent. If a government then imposes a new resource tax, the incidence of the tax will fall on the existing property owners or lease holders. Thus, there will be redistributive effects to be accounted for. If the government is the principal owner of the resource properties, this will be much less of an issue, except to the extent that they have leased the resources on a long term basis at a predetermined price that reflects the pre-resource-tax value of the rents.

In our view, the main reason for taxing resources over and above that of other general tax measures is precisely to acquire for the public sector a share of the rents generated from resources. In principle, special rent taxes could be imposed on other sectors. However, the argument is strongest for resource industries since those are where economic rents are most likely to reside.

Given that the main purpose of resource taxation is to capture rents, the appropriate form of taxation is one whose base is economic rents. We reiterate below the form that might take. For now we simply note that actual resource taxes seem to differ from rent taxes in significant ways. Unlike with the general income tax which includes provisions which allow the resource industries to understate capital income, resource taxes often overstate rents. This is because they frequently do not offer full deductions for all costs, particularly capital costs. Some systems tax revenues without giving any deduction for costs; others allow current costs to be deducted. As a consequence, they discourage investment activity in the resource industries, encourage the exploitation of high grades of resources at the expense of low grades, and make it difficult to impose high tax rates for fear of making the marginal tax rate greater than 100%.

2. Policies for Capturing Resource Rents

As we have discussed earlier, there are three alternative ways for the government to divert a share of rents to the public sector. They are as follows:

a. *Cash Flow or Cash Flow Equivalent Taxes*

The ideal sort of rent tax is a tax on the real cash flows of resource firms. For non-renewable resource firms, the base would include all revenues on a cash basis less all current and capital costs including costs of acquiring resource properties, exploration expenses, development expenses and any processing expenses incurred by the resource firm. For renewable resource firms, similar costs would be deducted including costs of property rights, harvesting costs, any renewal costs such as replanting or restocking, as well as any processing costs done by the firm. There should be no deductions for other taxes paid. Of course, cash flow accounting should be done from a social point of view so any external costs should be included as costs on a cash basis. It may also be necessary to require the firm to cover the external cost associated with shutting down, though that may be done by forcing firms to post bonds and/or through other forms of regulation. Both corporations and unincorporated firms should be subject to the tax. This is a relatively straightforward type of tax to administer, though there are likely to be incentives to evade. For example, there is an incentive to engage in transfer pricing for vertically-integrated firms as a way of passing rents forward to non-resource firms. (Note, however, there is no disadvantage to extending the base as far forward as is necessary for a vertically-integrated firm since if there are no rents downstream, there will be no tax collected.) As well, there is an incentive to have capital income masquerading as wage and salary payments to avoid the tax. These are inevitable consequences of a tax which applies differentially to some activities and not to others. In principle, the cash flow tax rate could be extremely high, approaching 100%.

The public sector may balk at a full-fledged cash flow tax since it generally implies that tax liabilities will be negative for growing firms. Although the cash flow implications of these may be beneficial for the firms, governments can raise tax revenues only with some welfare cost and they may prefer a system which smooths tax receipts into the future. Such a compromise is easily achieved with a modified cash-flow tax base in which the firm can capitalize cost deductions in a straightforward way. In particular, any costs which are capitalized receive a full nominal interest deduction based on the full book value of the capitalized cost. The rate of depreciation used for capitalization purposes is arbitrary. It may well be chosen by the firm subject to the constraint that tax liabilities cannot be negative. Such a system is equivalent to one in which negative tax liabilities are carried forward at full interest. It is therefore equivalent to a straight cash flow tax base.

b. *Auctioning of Leases or Property Rights*

Rents may be transferred to the public sector by requiring firms to bid for the rights to exploit resources. In the case of non-renewable resources, this would occur prior to the exploration stage. For renewable resources, the bid would be for a known stock of resources. As long as the bidding system were competitive and all bidders were equally well informed, the value of the bid would be equal to expected future net rents (net of future expected taxes) corrected for a risk factor. Furthermore, to ensure that optimal rents were obtained, the property rights obtained must be perpetual. If they were for a fixed term, there would be an incentive for the operator to extract the resource inefficiently.

Even with a well-functioning auction, the consequences can differ from that under a rent tax. For one thing, the auction will yield 100% of the expected value of the rents to the bidder, whereas the tax rate may be less than that. Under an auction, the cash flow consequences are much different as well. Net rents must be entirely paid up front, whereas with taxes they are spread out into the future. If there are any capital market constraints, this will be reflected in the size of the bid. Also, the risk effects can be different. Under the auction system, the firm is forced to bear the risk associated with resource exploitation whereas with the cash flow tax the public sector shares the risk. To the extent that the public sector is better able to pool or spread risk, the outcome may be more efficient. Of course one important reason why the public sector may be better at dealing with risk is that some of the risk facing the operator is the risk of higher taxes in the future. The time inconsistency which gives rise to this will be more severe under a system, such as an auction, which captures rents up front. Thus while this risk makes it more appropriate to use an auction system, it also reduces the price that bidders will be willing to pay for a long term lease.

The auction may be inefficient for various reasons. If bidding is not competitive, it will not be efficient. Also, if the auction requires firms to bid not only on a once and for all payment but also on a future royalty payment, the outcome will not be efficient since the firm will be induced to behave inefficiently in the future.

c. *Public Sector Equity Participation*

Finally, the public sector may obtain a share of the rents by taking on a share of equity in the firm in particular ways. One way of doing so is for the government to contribute to a share of the costs of exploiting a resource and claim an equivalent share of the equity of the firm. This would be financial exactly the same as a cash flow tax, though perhaps more difficult to implement. The public sector would have to identify both the cash costs and the revenues accruing on the relevant operation

of the firm. On the other hand, unlike with a cash flow tax, if the public sector actually does become a full partner in the ownership of the firm, it presumably has a say in the decision-making responsibilities that come with share ownership. As well, it may be privy to information that it would otherwise not obtain. This is in contrast with cash flow taxation where the government is a silent partner.

The above method involves the government providing cash up front and obtaining revenues in the future. The government could become an equity participant while avoiding these cash flow consequences for itself. Instead of providing money up front, it could deduct its share of the costs later on against dividends. This is referred to as acquiring *free equity*. As long as the costs were appropriately deducted with interest the scheme would be financially equivalent to the cash-flow equivalent schemes outlined earlier.

As with taxation but in contrast to auctions, equity participation schemes will divert less than 100% of the rents to the public sector. Furthermore, there may be an issue in the case of foreign firms of the extent to which foreign tax credits can be claimed against home country governments. Of course, that may be an issue with resource taxes as well.

3. How Actual Policies Differ from True Rent Collection Devices

Revenue-raising policies actually used differ from those outlined above in their design. This implies that they are not pure rent collecting devices, but distort decision-making as well. There may be various reasons for this, some of which involve other policy objectives by the government (e.g., capital income taxation, protection, etc.). However, it is also possible that policy makers are ill-informed about the proper design of rent collecting devices, or that purely political factors are at work. Rather than second guessing the reasons, we simply discuss the ways in which actual measures deviate from optimal rent-collecting instruments. We concentrate largely on measures specific to the resource industries.

a. *Tax Measures*

Historically, it has been the exception rather than the rule that rent taxes have been used in the resource industries. Indeed, there are very few examples of cash flow type taxes. We consider the various taxes in turn.

i. *Royalties/Stumpage Fees/Severance Taxes.*

Perhaps the most common form of resource charge has been a levy based on the

quantity extracted, variously referred to as a royalty or severance tax in non-renewable resources and a stumpage fee in forestry. It is difficult to understand the attraction of this type of charge apart from simplicity. Sometimes these levies have been viewed less as a form of tax than as a fee charged by the public sector for removing resources from public or Crown lands. However, from an economic point of view, they are equivalent to a production tax. In their simple form, they tax revenues with no accounting for costs. As such, they act as a disincentive for investment and extraction of resources and coincidentally generate less revenue for the public sector than could be obtained by a rent tax. Furthermore, since no account is taken of costs, they discriminate against high-cost revenue sources at the expense of low-cost ones. This effect of crude royalty systems is generally known as high-grading of the resource. In the case of mines, socially valuable but high extraction cost deposits are left in the ground. In selective logging operations, lower value stems are left unharvested and are often damaged and left to rot in the forest. Also, since costs are not deducted, they do not serve as risk-sharing devices by the public sector, nor do they provide any assistance with the cash flow of firms as is the case with other measures. Against this must be set the fact that production taxes may have a role in correcting for externalities associated with resource production. However, this would not justify their use as primary revenue collection devices.

The effect of production taxes can differ according to whether the tax rate is based on quantity produced (per unit tax) or upon the selling price (*ad valorem*). In principle, an *ad valorem* rate can always be chosen such that it is equivalent to a given per unit rate. However, when prices are changing, maintaining that equivalence would require constantly changing the tax rate. If the tax rates remain fixed while prices change, the two will have different effects. In particular, when prices rise, the *ad valorem* tax rate rises relative to the per unit and vice versa. This implies that the *ad valorem* tax has some risk-sharing effect that the per unit does not have, and in periods of rising resource taxes, it discourages investment more. Similarly, when the quality of a resource varies within a given deposit (e.g. less rich ore seams in a mine, and different tree species within any part of a forest concession), maintaining equivalence between an *ad valorem* and specific tax rate would require different per unit rates for different parts of the deposit which is extracted.

Several countries have moved away from simple per unit royalty systems and export taxes in recent decades. These include Bolivia and Indonesia for hard minerals, Colombia for oil, and Jamaica for bauxite. Sabah and Indonesia have also moved in a similar direction in the case of tropical timber by varying the royalty rate by type of tree species.

Increasingly, royalty schemes have been designed to be more sophisticated than simple production taxes. There are two main ways in which this has been done. For

one, some royalty bases have been defined to be revenues net of current costs. Sabah has refined its tropical timber royalties by allowing a deduction meant to represent presumptive logging costs. This goes part way towards making royalties reflect rents. The other method is to make the royalty rate itself a sliding scale based on either resource prices (an *excess price tax*) or on the quality of the resource. These are sometimes referred to as *windfall taxes* reflecting the fact that purpose has been seen as a way of creaming off resource rents generated by price increases. Such sliding royalty systems have been used for oil (Peru and Malaysia for example) tropical timber (Sabah) coal (Indonesia) and tin (Malaysia). Again, this is an imperfect way of taxing resource rents in general, although the procedure of basing royalties on price can succeed in obtaining changes in rents from existing resource firms who have benefited from an unexpected increase in price. However, this is done at the expense of discouraging incremental investments. The latter can be mitigated in some instances by basing the royalty rate differentially on new and existing resource properties. Such a procedure will work only once.

ii. *Income-Based Taxes*

Resource properties are usually subject to general income taxes. However, in some instances, taxes specific to the resource industries are also based on some measure of income. In such cases, the tax is often designed in similar ways to the general income tax and has built into it some of the same biases. That is, it affords rapid write-offs for acquisition costs, exploration and development, and often gives a depletion allowance. Although this generates some revenues, it also has the effect of providing a subsidy to marginal projects. That is, average tax rates are positive while marginal tax rates are negative. Furthermore, the way such taxes have been implemented in most developing countries (e.g. for coal in Colombia and hard minerals in Indonesia) the rate of return to equity at which they become effective has tended to be extremely high. Thus they have not been very effective collectors of excess profits or rents.

We have outlined earlier how income-based taxes could be designed to reflect economic rents, using a modified cash-flow approach. However, such systems have not been used. Elements of cash flow taxation have appeared in some developed countries. For example, the mining tax regime in Alberta, Canada has the following features. It is basically a cash flow tax except that a royalty is also applied until capital and start-up costs have all been deducted. A similar system is used by the Canadian government to tax oil and gas on federal Crown lands. Thus, the principle of cash flow taxation has not been completely ruled out. However, these systems are not fully efficient since they deny the full tax advantages of expensing all capital costs.

iii. *Property Taxes and Leasing Fees*

Some tax regimes impose an annual rental fee or charge for the use of resource properties. This is often done in the case of timber concessions and plantations in states of Malaysia. If their rates were such as to reflect the true capital value of the properties being used, they would be like a rent tax. However, they are typically set at arbitrary and more or less nominal rates. It would be difficult to administer such a tax based on the true economic value of the resource property in question since market values do not exist. Thus, some administrative discretion would be required. If an annual rent tax is to be charged it seems preferable to use a proper rent tax.

iv. *Export Taxes*

Export taxes are frequently used in developing countries as a source of revenue from primary resources. In primary product exporting countries, they have been a major source of government revenue. In the case in which the country is a price taker on international markets, an export tax has exactly the same effect as a production tax from the point of view of the producers. However, consumers pay a lower price under the export tax. There may therefore be some distributive reasons for preferring an export tax, though it may be more for reasons of administrative simplicity. However, countries have found that export taxes on many resource products (e.g. rubber in Malaysia) have been quite regressive and have tended to eliminate these taxes in favor of other more general taxes on spending and income. In many cases, domestic consumption is a small proportion of production and so the differences in the revenue implications of production and export taxes may not be great. However, the efficiency costs arising from diverting high value resources to lower value domestic uses depends not on the absolute value of domestic use relative to exports, but rather on the responsive of domestic demand to price changes caused by the export tax. Taxes on exports to induce local downstream processing industries can also be a very costly way of dissipating resource rents. Even in cases where the resource-exporting country might have a long term comparative advantage in further processing, the use of export taxes to speed up the process can be very costly.

The same shortcomings of production taxes as rent collectors apply to export taxes. On the other hand, export taxes may be justified if the country has some monopoly power in world markets by the usual optimal tariff arguments. If so, that would be a separate justification for export taxes over and above rent collection devices.

b. *Auction Systems*

We have listed auction systems earlier as one of the ways in which rents can be extracted from resource producers up front. However, they tend not to be used much, especially in developing countries. Presumably one reason is that the conditions do not lend themselves to competitive bidding procedures. Many resource projects are large and may not involve more than one different investor at the same time. For whatever reasons, individual deals are struck with resource producers involving different types of public participation. These can take various forms as discussed next. One feature of such contracts which distinguishes them from other arrangements is that they tend to involve a major element of administrative discretion. That may be viewed as a drawback from an economic point of view when compared with schemes for which eligibility and conditions are non-discretionary.

c. *Production Sharing*

There are various non-tax ways in which governments acquire shares of the proceeds of resource projects. Two common methods are by sharing of the output of production and government acquisition of equity shares in resource firms. Variants of the first of these is considered here.

The simplest case is that in which the government imply takes a given share of the product. The analogy would be a system of share cropping in agriculture in which a landowner allows a tenant to farm a plot of land in return for a share of the crop produced. The basic scheme is identical to an *ad valorem* production tax at the same rate. It differs from a tax on pure rent since no costs are deducted. Since it is *ad valorem*, some risk-sharing is implicit in the scheme.

Since production sharing schemes are subject to negotiation, the proportion of sharing could vary from project to project. In this way some account can be taken of different potential rents. However, as long as costs are not explicitly deducted, such schemes will not reflect pure rents.

Some schemes account for costs partially by having the production sharing cut in only after some minimum guarantee level of revenues for the firm (e.g. oil in Indonesia). As well as allowing the firm to cover some part of initial costs before sharing its output, this provides an additional measure of risk-sharing. However, even if the minimum were set such that total costs were covered, there would still be a marginal disincentive involved in such schemes once the production sharing begins to apply.

A variant on production sharing is a requirement that a certain proportion of production be "made available" to the domestic market. If such local market sales

are at the prevailing world price, this does not transfer any rents. If the price is less, then some rents will be transferred, and it will be similar to a simple production sharing arrangement. Of course, if the sales at subsidized prices are to private traders, the rents will not accrue to the public sector. Lack of clear specification of the terms of such sales in the local market (including the price and the eligible buyer) can be a source of contention with resource investors (e.g. aluminum in Indonesia).

d. *Equity Participation*

Finally, governments may negotiate to adopt equity positions in resource firms. Again, this can take various forms, and the ability to obtain rents depends upon the form taken. At one extreme, the government could simply purchase shares of a resource firm on the open market. Divestiture of a given proportion of shares to local investors within a specified time period is a standard condition of foreign hard mineral investments in Indonesia. The government has often put forward as an obvious investor in such circumstances. Since the market value of the firm should capitalize all expected future net rents of the firm, this would not be expected to yield any net revenues to the government. All it would do is to provide the government with whatever decision-making authority goes along with share ownership. To facilitate rent transfer to the government, the government must succeed in obtaining share holding privileges at below the market value of the shares.

At the other extreme, the government may simply take "free equity" in the firm, thereby entitling itself to a share of future dividends of the firm. This will differ from a rent tax regime by the fact that no implicit deduction is given for the initial equity put in by the firm. This may approximate the initial capital costs incurred by the firm. It would then be similar to a royalty system with current costs deducted. There are many instances of such free equity arrangements, especially in hard minerals (copper in Panama, copper and nickel in Botswana, and uranium in Gabon).

Instead of taking free equity, the government may pay some price for it. As mentioned, to obtain some share of the rents, the price would have to be less than the market price of the shares taken. The could be done up front or it could be made later by reducing future dividends. Equity sharing schemes of this form will be equivalent to rent taxes if the payment made by the government is equal in present value terms to an equivalent share of the cash costs of the project. If this payment is made up front, it would have the identical financial effect as a cash flow tax. The only real difference is that the government obtains voting rights. If the payment is spread out into the future (e.g., taken out of future dividends), it should be carried forward with interest. In either case, the government will obtain only a

share of the rents rather than the entire rents under an ideal auction system.

3. Other Design Issues

There are a number of other design issues involved in resource taxation which may cause them to differ from ideal rent taxes. Some of them are as follows.

i. *The Time Horizon*

As mentioned, arrangements with the private sector for sharing rents may be viewed as being for a limited period of time. This may be because of conscious design, as in the case of forestry concession. Or, it may be because of the inevitable inability of governments to commit to fixed policies for long periods of time. In any case, the result is an inefficiency which is hard to avoid.

ii. *Shut-Down Costs*

Many non-renewable resource operations face costs of shut-down such as clean-up costs to avoid environmental damage. Simply requiring firms to meet such costs may be unenforceable since they may be able to avoid them by just abandoning the site. Clean up could be enforced by requiring the firm to post bonds against the cost of cleanup, or, equivalently, by imposing a withholding tax in respect of resource management which is refundable once the clean up is completed.

iii. *Discretionary Policies*

Some sorts of policies may involve administrative discretion. Economists generally view these sorts of policies with some suspicion and prefer those for which the terms of eligibility are automatic. Discretionary policies lend themselves to costly rent-seeking activities as well as to possibilities for dishonest behaviour.

iv. *Jurisdictional Issues*

In many countries jurisdiction over resources is decentralized at least partly to lower levels of government. Examples include Malaysia and Canada. This can give rise to problems of tax coordination among various levels of government as well as to different fiscal capacities among lower levels of government. As the literature on fiscal federalism makes clear, the latter can cause inequities across the federation and inefficiency in the allocation of mobile factors of production in favour of the wealthier states. Many countries have instituted mechanisms to enable at least

some share of resource rent to be shared among states.

v. *International Aspects*

Many of the firms that operate in less developed countries are foreign firms. This gives rise to various other issues. For one, certain tax measures may be preferred to others to the extent that foreign tax crediting is facilitated. Use of the income tax system rather than free equity or production sharing arrangements may have that property. As well, the ability of foreign companies to shift profits through transfer pricing and other means will limit the extent to which some types of taxes on resource rents will be effective. This may help to account for the growing use of other measures such as royalties, equity participation and leasing of property rights.

4. Conclusion

Developing country governments have become increasingly conscious of the desirability of levying taxes on economic rents arising from natural resources occurring within their boundaries. At the same time they have shown increasing sophistication in modifying the crude fiscal instruments that have been traditionally used for this purpose in order to both decrease the efficiency costs arising from the use of imperfect rent taxes and increase the proportion of the rents that they are able to attach for public purposes. The time has now been reached in many countries at which the gains from further refinement of what are basically very crude taxes such as royalties and export levies might be far exceeded by replacing them with much simpler forms of pure rent taxes.

APPENDIX:

Measuring Marginal Effective Tax Rates in Resource Industries

The marginal effective tax rate measures the difference between the pre-tax rate of return on the marginal investment and the after-tax return to savers. The latter can be inferred from observed market rates of return. The former is more problematic because the marginal investment project cannot be identified. Instead, the return on the marginal investment project is inferred from the user cost of capital. Consider, for example, the case of depreciable capital discussed above. The value of the marginal product of one unit of capital in real terms is given by (9′). To convert it into a rate of return expression, two steps must be taken. First, the entire expression is divided through by q_t so it represents the marginal product per dollar of capital. Then, to make it a rate of return the economic depreciation rate ($\delta - \Delta q/q$) is subtracted out. This leaves r as the rate of return on the marginal investment. That is also the rate of return on saving, so the marginal effective tax rate is naturally zero in the absence of taxes.

Suppose now we take a very simple, but representative, corporate tax system. Let the rate of depreciation for tax purposes be σ applied on an historical basis to undepreciated capital. Suppose that interest deductions are allowed on debt, but no deductions are allowed for the costs of equity. Also suppose that there is an investment tax credit in place at the rate ϕ based on gross investment. The tax rate is u. Then, it can be shown that the expression for the value of the marginal product of capital (9′) must be amended as follows:

$$p_t F_{K_t} = \frac{q_t\left(\delta + r - \frac{\Delta q_t}{q_t}\right)}{1-u}\left(1 - \phi - \frac{u\sigma}{r+\sigma}\right). \qquad (9'')$$

where r is the real cost of funds to the firm. Suppose a proportion β of the firm is financed by debt and the rest by equity, and the nominal costs of debt and equity are i and ρ respectively. Then, given interest deductibility, r is given by:

$$r = \beta_t i_t(1-u) + (1-\beta_t)\rho_t - \pi. \qquad (10)$$

In interpreting equation (9″), note that $u\sigma/(r+\sigma)$ is the present value of future tax savings due to depreciation. Thus, given the investment tax credit, the second bracketed term on the right-hand side of (9″) can be thought of as the effective price of new investment.

The pre-tax rate of return can be constructed as above. It is given by:

$$r_g = \frac{\left(\delta + r - \frac{\Delta q_t}{q_t}\right)}{1-u}\left(1 - \phi - \frac{u\sigma}{r+\sigma}\right) - \delta + \frac{\Delta q_t}{q_t}. \qquad (9'')$$

Given the tax parameters and estimates of the true depreciation rate and the cost of funds to the firm, r_g can be calculated. To obtain the marginal effective tax rate, the after-tax rate of return r_n must be subtracted from r_g. The after-tax rate of return is given by $r_n = \beta_t i_t + (1-\beta_t)\rho_t$.

Next, we want to apply the same methodology to a non-renewable resource firm. We consider a firm which is simultaneously involved in exploration, investment in mining facilities, and extraction. Inventories are excluded so that sales equal extraction; it would be relatively straightforward to add inventories. The taxation of resources is notoriously complex in practice. For illustrative purposes we consider a relatively simple scheme which incorporates most of the key issues.

In the exploration stage, the firm hires current inputs L at a price W and produces a depletable asset according to the strictly concave function $S(L)$. (We are deleting time subscripts for simplicity.) It then invests in mining capital K at a price Q to make the asset ready for extraction. The production function is $Z(K,F)$ where F is the current use of previously discovered asset. This is the only stage at which depreciable capital is used, though it would be straightforward to allow for it at either of the other two stages. Finally, the firm extracts an amount Y of the resource according to the strictly convex nominal cost function $C(Y)$ and sells it at a price P.

The tax regime facing the firm consists of two taxes — a corporate tax and a simple royalty or severance tax based on total revenues. The corporate tax involves write-off provisions for depreciation and interest costs and an investment tax credit as above, as above as well as some deduction for the use of the asset itself (a depletion allowance). We assume a royalty tax rate of g based on total revenues. The corporate tax liability will be written:

$$T_c = u[PY - C(Y) - WL - \sigma A - R - iB] + fQI.$$

where A is the accounting value of the capital stock for tax purposes. Here, R is the depletion allowance and is defined to be:

$$R = t(PY - C(Y) - \sigma A)$$

though most systems are more complicated than that. All other variables are the same as defined earlier.

Given this, the expression for the cash flow of the firm is defined to be:

$$CF = PY(1-u(1-t)-g)-C(Y)(1-u(1-t))-WL(1-u)-Q(1-f)I+\sigma Au(1-t)$$

where the accounting capital stock is defined as in (6) and investment is related to the real capital stock as in (5).

The firm maximizes the present value of its cash flow discounted by the nominal cost of funds $r + \pi$ defined by (10) and subject to the following two resource constraints:

$$\int_0^\infty (Y - Z(F,K))dt \leq 0$$

$$\int_0^\infty (F - S(L))dt \leq 0.$$

The first states that the total resource extracted cannot exceed the total developed, while the second states that the total resource developed cannot exceed the total found. (In a more general version of this problem, this constraint would have to hold at each point in time.) The solution to this problem yields the following marginal conditions to be satisfied:

$$\frac{p-c'}{q}Z_K = \left(\frac{\delta + r - \frac{\Delta q_t}{q_t}}{1-u(1-t)-g\frac{p}{p-c'}}\right)\left(1-\phi-\frac{\sigma u(1-t)}{r+\sigma}\right)$$

$$\frac{p-c'}{w}Z_F S_L = \frac{1-u}{1-u(1-t)-g\frac{p}{p-c'}}$$

$$\frac{\Delta(p-c')}{p-c'} = r - \frac{rg}{(1-u(1-t))(1-\frac{c'}{p})}.$$

The first of these is simply the pre-tax marginal product of capital. To convert it to r_g simply subtract $\delta - \Delta q/q$ as before. The second equation is the social value of marginal product per unit of the current input L. An effective tax rate can be obtained directly by subtracting unity from it. The final equation is a form of Hotelling's rule. It gives the pre-tax rate of return to society from not extracting the resource. It can be converted to an effective tax wedge by subtracting r_n. These can be used to calculate marginal effective tax rates for a given institutional setting. Notice that the corporate tax and the royalty system interact in each of the decisions of the firm — the current input decision, the depreciable capital input decision and the extraction decision.

Suggested Readings

For a general treatment of the economics of both renewable and non-renewable natural resources see:

Hartwick, John M. and Olewiler, Nancy D., *The Economics of Natural Resource Use* (New York: Harper and Row, 1986).

A survey of the literature on taxes and other instruments for obtaining revenues from, and regulating, various types of natural resources (fisheries, forestry, mining, oil and gas, and hydro-electricity), see:

Heaps, Terry and Helliwell, John F., "The Taxation of Natural Resources," in Alan J. Auerbach and Martin Feldstein (eds.), *Handbook of Public Economics, Volume I* (Amsterdam: North-Holland, 1985), 421–72.

A general outline of the special problems of taxing natural resources in developing countries may be found in:

Gillis, Malcolm, "Evolution of Natural Resource Taxation in Developing Countries," *Natural Resources Journal* **22**, July 1982 620–48.

A survey of the theory and calculation of marginal effective tax rates, including alternative approaches and applications, may be found in:

Boadway, Robin W., "The Theory and Measurement of Effective Tax Rates," in J.M. Mintz amd D.D. Purvis (eds), *The Impact of Taxation on Business Activity* (Kingston, Canada: John Deutsch Institute), 60–98.

An application of the role of rent taxation and the concept of effective tax rates to non-renewable resources is developed in:

Boadway, Robin W., Bruce, N., McKenzie, Kenneth. J., and Mintz, J.M., "Marginal Effective Tax Rates on Capital in the Canadian Mining Industry," *Canadian Journal of Economics* **20**, February, 1987, 1–17.

Some general issues of taxation in developing countries are surveyed in:

Newbery, D.M.G. and Stern, N.H., *The Theory of Taxation for Developing Countries* (Washington: The World Bank), 1987.

For a recent treatment of the effects of taxes on investment in developing countries see:

Shah, Anwar (ed.), *Fiscal Incentives for Investment in Developing Countries* (Washington: The World Bank), May 1992.

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